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March, 1935

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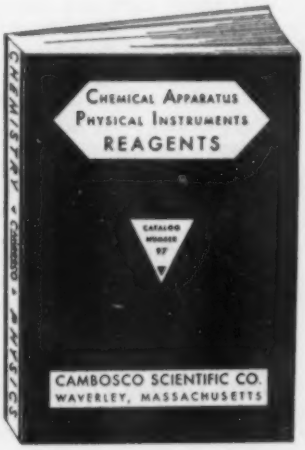

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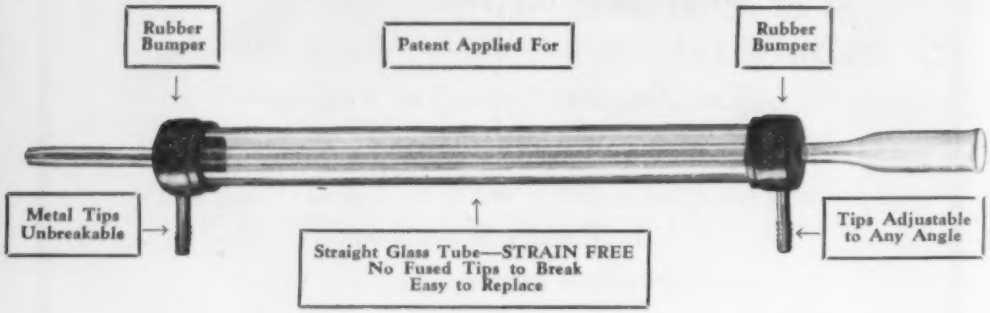

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SCHOOL SCIENCE AND MATHEMATICS

VOL. XXXV MARCH, 1935 WHOLE NO. 302

MATHEMATICS AS AN ENTRANCE REQUIREMENT AT THE UNIVERSITY OF WISCONSIN

BY RUDOLPH E. LANGER

University of Wisconsin, Madison, Wisconsin

Near the close of the school year, in June 1934, the University of Wisconsin adopted a new set of regulations for admission, which embodies a number of departures from the older entrance requirements. In so far as these new requirements imply a modification in the status of individual preparatory subjects, they concern the mathematical subjects more than any others in the high-school curriculum. It is important that the changes which were made be understood, not only by teachers of mathematics and by administrative school superiors, but by secondary school teachers at large. The purport of the following is, therefore, to describe in brief the new status of mathematics, and at the same time to present an analysis,—say, at least one possible analysis—of the whole problem of a mathematics requirement. It is hoped that this may reveal to some extent the considerations which were thought pertinent, and which, therefore, were in some measure of influence in the framing of the new University regulations.

For many years and up to the present time mathematics, to the extent of a year each of algebra and geometry, was a requirement for admission to the University of Wisconsin as to almost all other universities. Until relatively recent times neither the propriety nor the justice of such a regulation was ever seriously questioned. Mathematics was regarded almost universally as a traditional subject, and as one of wide and evi-

dent usefulness. It was believed to be pre-eminently suited as a medium for the development of many desirable intellectual faculties, and was in short looked upon as fundamental in any educational plan. In this position mathematics began to be insecure soon after it was more or less generally recognized that the earlier notions of the extent of transfer of training were extravagant, and educational thought swung to the opposite extreme. Objections against the allotment of school time to mathematics then became more and more frequent, until at the present the advocates of the subject find themselves on the whole oftenest in the defensive position.

The purposes and aims which guide our schools and educators from time to time in the pursuit of their function of training students are not stable but changing ones. They are subject externally to the pressure impinging upon the schools as a result of changing social conditions, and internally to the influences of changing educational thought. Rightly or wrongly, as the case may be, much of this thought unquestionably tends at the present time toward minimizing the values to be derived from elementary mathematical study. As a result many school administrators had come to regard themselves as unduly handicapped by the University admission requirement. They felt that this requirement affected not only those students who were destined for the University, but that through the element of prestige which attaches to the college preparatory subjects it also influenced unduly the bulk of students who were in fact completing their period of formal education at the high-school stage.

It is not hard to see how under these conditions an increasing and finally an insistent pressure for an abolition of the mathematics requirement should have been brought to bear upon the University by the organizations of secondary school executives. The University had no wish to ignore this pressure. In our public educational system the University and the high school are co-ordinate units, and a satisfactory functioning of the whole requires the utmost of willing co-operation between one part and another. It is proper that each part should see to and insist upon its own peculiar needs, but beyond that point it is not proper that it should go. The University, therefore, undertook a review of the mathematics requirement as it concerned its own needs. Each department of the College of Letters and Science was asked to give thought to the matter, and to report

as to whether or not the requirement was necessary to the proper conduct of its work.

Now it will be immediately evident that in some cases the requirement would have to be found dispensable. For a study of the languages, or of history, or of journalism, or of a few other subjects, mathematics cannot be regarded as prerequisite. On the other hand the survey revealed to a very striking degree that a background of elementary mathematical training is essential to serious work in a vast array of fields of which many are in no way obviously related to it. It revealed also, and this should not be without interest, that the scholars of the college faculty, were almost unanimous in their belief that the study of algebra and geometry is desirable on general educational principles, and that an omission of these subjects from a student's program should be looked upon as a mistake.

The entire matter was naturally of the most direct concern to the members of the university's department of mathematics, who found themselves faced by the problem of determining the real issues involved in the proposals for a change. Were they to stand unconditionally for a retention of the requirement of mathematics, or were they heedlessly to sanction its abandonment? Of these alternatives, thus baldly put, the first, i.e., the unqualified retention, seemed not entirely justifiable; and the second, i.e., the abandonment, seemed both dangerous and unwise. The following are some of the reasons for these conclusions.

Firstly, as to the justice of a requirement. Here it must be observed that there was no attack upon mathematics as a desirable subject for some or even many students. It was and is generally recognized that our age is pre-eminently a scientific and technical one, and that without the study of mathematics there could be neither scientists nor technologists. On the other hand, it cannot be denied that there are occasional students who, reasonably or otherwise, foster a dislike for the mathematical subjects. In extreme cases such students are found to be totally incapable of attaining passing grades in them. Yet in their own way such students may be of high calibre, and ones whose interest will forever remain far from the scientific. The University has much to offer such students, and to deny it them unconditionally because of their mathematical inabilities, seemed a somewhat extreme and pedantic standpoint which it would be difficult really to defend.

On the other hand the unqualified abandonment of the requirement seemed a course which promised to result in much confusion, and in a very definite lowering of the standards in much of the University's work. Reasons for this belief were many, though, on the whole they were simply those which cannot fail to present themselves to anyone giving serious thought to the matter. It is, however, well that serious thought should be given to this matter, for if any lasting value to the teaching of mathematics is to ensue from the criticism to which it is and has been exposed, it will be in this, that it may compel mathematics teachers in general to look to their position, to take stock of their wares, and to clarify their minds as to their objectives, and as to the reasons upon which they would justify the retention of mathematics as a core unit in the educational curriculum.

The rôle of mathematics in the educational scheme is twofold: On the one hand it is a subject of culture—a notable one in that category—while on the other hand it is an intellectual tool which is indispensable for the acquisition of an understanding of and a control over a vast domain of other useful and important knowledge. Counting, measuring, estimating and computing, and the recognition of shape and the interrelations of forms, these are activities in which every member of any civilized community takes part, sometimes consciously but much more often without bestowing upon them any active thought. In their simplest exercise these activities are often practical in the sense that they safeguard material advantages. But the doing of small sums in everyday life is not the totality of them. Far from it! Surrounded as we are by a scientific world, the intelligence with which we react to the many phases of our environment is conditioned to a large degree by the extent to which we are capable of a measure of quantitative thinking. Such quantitative thinking, or mathematical thought, is involved intimately in the daily evidences of all human affairs. Without it there would be no basis of order, and positiveness and certainty would give way to chaos.

Even leaving aside all material considerations, we are all in constant and continual contact with the physical embodiments of mathematical ideas. In nature, in architecture, in art or in the designs of machinery—in all these and in innumerable other contacts—we encounter magnitudes and proportionalities, and curves and shapes, etc.. all in manifold variety and inter-rela-

tions. Our reactions to this complex of environment depends largely upon our training, for the intelligent mind perceives and appreciates, and enjoys beauty and the recognition of purpose, where the untutored neither perceives nor enjoys. We are, of course, not always aware of our quantitative appraisals. Yet to deny their presence would be as nonsensical as to deny the distinction between the deportment of the boor and the person of fine culture. Nor are the cultural elements of mathematics to be sought alone, or even mainly, in its applications. For it is in itself a highly distinctive mode of human thought, an intellectual activity which has never failed to win respect and admiration. It has found adherents and enthusiasts in every historical age and among all civilized peoples.

These facts should be urged for careful consideration before any curtailment of the mathematical subjects in the curriculum is undertaken. These subjects represent established values, and do so for all students, whether their future lies in the University or not. The student who omits the study of algebra and geometry comes to graduation from the high school from four to six years removed from his contacts with arithmetic in the grade school. He lacks the most elementary appreciations, conceptions, and skills in numerical or spatial relations. He knows or remembers next to nothing of the significance of porportions, and the laws by which they combine, or of the use of graphs or tables, or of anything of the sort. Granted that he has been given a background for good citizenship, and that this accomplishment is desirable and important, is it evident that the attainment of this goal is conditional upon the exclusion of training in the mathematical appreciations? Such appreciations far more than most other attainments will retain their significance, and will resist being outmoded by time. The explicit formulas, may, to be sure, and perhaps will be forgotten. But the values of mathematical training do not evaporate with them any more than a study of history turns to waste when the dates are no longer retained.

The cultural values of mathematics, intangible as such values in their very nature must be, are inevitably vital. For the high school itself there must be added to them other values which, though they perhaps concern mathematics itself less, are still significant for other pedagogic reasons. Among these should be mentioned such points as the eminent suitability of both algebra and geometry as subjects for high-school instruc-

tion. They are both within the reach of the abilities of all normal students, and present subject matter which is significant to them. Each of these subjects presents a medium for the cultivation of care and accuracy, and for the sifting of the essential from the unimportant, and each looms forth by virtue of the definiteness of its results from among the many subjects which stand mainly upon bases of opinion and plausibility. In our present educational scheme, moreover, the students' sole training in hard and unequivocal logical reasoning is that which is imparted in the course in geometry.

These points should argue for mathematics a secure place in the high-school curriculum. If they do not speak for a requirement, let it be put down to the fact that cultural values are the least apt to be successfully imparted by compulsion. However, the position of mathematics as a tool is still to be discussed. Here it must be observed that the trend of all sciences, of the social sciences no less than of the natural, is definitely and rapidly in the direction of increasing precision and exactness. This is true both as to their concepts and as to their methods. They are, in a word, becoming constantly more and more mathematical. Intelligent work in any of these subjects, and together they comprise a great portion of the entire field of human knowledge, is, therefore, conditioned upon some facility with the elementary mathematical ideas, and upon some skill in the mathematical operations. This preparation is by all odds most profitably obtained in the high school, for in mathematics perhaps more than in any other subject the element of time is of the utmost importance. It is not possible, with any real success, to cram into a short period an extended chain of mathematical ideas. They must be mastered in sequence, and must be given time to become part of one's instinctive mental equipment. A student coming to the University without this equipment is inevitably unqualified for participation in much that the University offers. He would by omitting the proper subjects years before, namely, in the early high-school years, have unwittingly closed upon himself the door to many great fields of learning. His maturer interests may often be precisely those from which he would find himself barred. The danger of this is doubtlessly very great. The mathematics requirement in the past has certainly prevented many students from preordaining themselves to careers which would have been regretted later. A removal of the requirement should be consented

to only if this danger can be safeguarded against. To keep this point in mind, is to have the key to the new University regulation, which may now be briefly described as follows:

Admission to the University, and the subsequent standing of a student in the University, are henceforth to be upon two distinct bases, the *restricted* basis and the *unrestricted* basis. The student who has not taken, or who has failed the high-school mathematics, may enter the University, but only on the restricted basis. To be eligible for unrestricted admission the old requirement of algebra and geometry must still be fulfilled. The term "restricted" in this classification applies solely to the freedom with which the student may choose for himself from among the courses offered by the University. The extent of the restriction is announced in the University catalogue, from which the following may be quoted; it says in part:

"Unrestricted admission to the University is admission which opens to the student all college courses and fields of study to which freshmen are eligible, and insures full freedom of choice among all the college majors and fields of specialization. Restricted admission opens to the student only such college courses and fields of specialization *as do not require high-school mathematics* as a background." A student on restricted standing will *not* be admitted to the College of Agriculture nor to the College of Engineering, and in other colleges may *not* major or specialize in any one of the following fields of study, i.e., Astronomy, Biology, Chemistry, Commerce, Economics, Geology, Mathematics, Medicine, Pharmacy, Philosophy, Physics, Physical Geography, Political Science, Sociology or Psychology, and he may *not* graduate from the School of Education with either a major *or a minor* in any one of these subjects.

You will observe the extent to which a student without mathematics is excluded from the University. It may be, of course, that in some instances this exclusion will not be of moment, and that it will in no way hamper the student in the pursuit of his chosen career. The students for which that will be true are precisely those for whom the old requirement was not justifiable, and for them the new regulation offers a flexibility which the old did not possess. They have been released from mathematics, and by the same token the mathematics teachers have been released from them. Though it is desirable that mathematics be appreciated and studied as widely as possible, no asset is to be found in uninterested, unwilling or

antagonistic students. No subject can draw any but an unreal vitality from the source of an unreasonable complusion. On the other hand, the long list of subjects which can be seriously studied only by the mathematically prepared, should, if presented to a student, give pause to any tendency toward an unreasoning avoidance of the mathematical subjects. It should even emphasize for him the great rôle which these subjects play. It is suggested that teachers of mathematics will find after due reflection upon the facts that their positions, both with respect to their students, and with respect to their colleagues, have not been weakened by the change in the University's requirements. Perhaps, even, they may find in the facts an incentive for teaching their subjects with renewed and increased enthusiasm.

SCIENCE AND UNEMPLOYMENT

No one can or would deny that frequently the introduction of labor-saving machinery in an established industry brings about temporary reduction in the amount of labor required to produce a given quantity of goods or services. Sweeping a microscope continuously over the field and seeing mainly these transitory results, one might easily get the impression that the normal effect of applying science to industry was to throw people out of work and impair standards of living. That is exactly what many loud-spoken and presumably sincere well-wishers of society are saying at the present time. Their remedy for our current sickness is for science to take a holiday; to limit the use of machines, prohibit the making of improvements in them, and wherever possible supplant them with unimplemented labor. In passing it might be noted that those who advocate solving the problem of unemployment this way are never very consistent. They would still use pick, shovel and wheelbarrow in building roads rather than teaspoons and buckets although clearly the latter would require a vastly greater number of workers per cubic yard of earth moved.

Even a microscopic survey of the results of applied science might disclose some disquieting counter-trends, however. The whole course of history during the past 150 years, and particularly during the past 50 or 75 years, is marked by an increasing number of fundamental science discoveries which have led to the creation of entirely new industries or services. In no sense have these tended even temporarily to diminish labor. Rather they have in addition to creating new openings for employment increased from the start the demand for labor and materials in existing industry.

Nor is the conclusion drawn from a hasty microscopic examination of cases where machines have temporarily displaced labor a very certain one. If we have a bit of patience in our viewing we can hardly escape the conclusion that almost invariably the first temporary displacement is followed by a substantial increase in the total number of men and women directly or indirectly employed. A cheapened or bettered product as a result of advancing science has in the past almost always stimulated demand in increasing proportion.

The Milvay Note Book

REVISION OF ENTRANCE REQUIREMENTS IN MICHIGAN COLLEGES

By George E. Carrothers

University of Michigan, Ann Arber, Michigan

It is distinctly encouraging to note the tendency of the North Central and other regional accrediting associations to place on the retired or emeritus list their long-used but out-worn standards for accrediting colleges and secondary schools. The North Central Association in particular, instead of continuing rigid standards, is beginning to ask each member institution to declare its purposes and objectives and then to try to hold the institution to excellent performance in its chosen field or fields. This gives promise of large usefulness for both secondary and college education. Imbued by the same high purpose, an increasingly large number of state universities are beginning to take themselves "off the backs" of secondary schools in their several states. The revisions in entrance requirements made recently at the University of Michigan is an example of the kind of encouraging action now being taken by these large universities.

In a day when secondary schools are drawing students from such widely varying groups, opportunity for choice of courses in high school takes on new importance. The revision in entrance requirements recently adopted by the University of Michigan and by practically all other colleges in the State, makes possible a better choice of subjects and courses in secondary schools, and at the same time provides for unconditional entry into college if a superior quality of performance has been maintained in high school. The change is a natural outgrowth of the recognition of individual differences in pupils and directly in line with progressive educational tendencies being followed by other leading colleges and universities.

It is beginning to be recognized that there are a few youths who seem to have blind spots for certain subjects. For example, a pupil in one of Michigan's best secondary schools this year seems unable to get mathematics even though she has nearly an A record in English and other subjects. It is also noted that others have their chosen schedules so crowded they are unable to take courses in every field formerly required for college entrance. Boys in farming communities often want to take four

years of English, a like amount of social studies, science, mathematics, accounting, animal husbandry, horticulture and other subjects. Their schedules are too crowded to permit the study of foreign languages. Boys in cities often desire to give special attention to industrial and technical courses. Girls in both city and rural high schools need time and opportunity to give attention to accounting, clerical and stenographic work, to home economics, hygiene and health, to homemaking and similar interests. These pupils and others in similar situations merely on account of having taken or having omitted a certain subject will not now be barred from entering if they decide later that they want to go to college. They will, however, be expected to present a good record of achievement in the high school and they will be expected to enter the type of work in advanced education for which they made special preparation in the secondary school.

The revised entrance requirements will be both a special boon and a real challenge to pupils in small high schools. In the larger high schools even at present it is possible to offer such a variety of courses that the interests and abilities of practically everyone can be served. Inasmuch as it is necessary in many of the smaller schools for every pupil to take every subject offered and to obtain either an earned or a gratuitous passing mark in order to graduate, it is of prime importance that provision be made for courses which most nearly meet the needs of all pupils enrolled. When pupils are compelled to take certain courses merely because they are traditionally acceptable there develops a tendency among teachers to be lenient with those pupils who seem to have unusual difficulties. This practice frequently leads to leniency for pupils in all courses. With a wider opportunity for choosing subjects of interest, pupils can be held to a better performance in all courses. A chance to choose is always a stimulation to action and even though the opportunity for choosing is not greatly widened by the present revision, it will doubtless be a challenge to pupils to do better work in the courses they do take. In turn, teachers will try to hold pupils to better performance and again in turn pupils will develop habits of achievement instead of habits of doing shoddy work and of failing.

Carefully planned studies show conclusively that pupils who do good work in high school have a tendency to do good work in college. There is an abundance of evidence to show that right attitudes toward education and good habits of performance are

much more apt to predict good achievement in college as well as successful performance in other phases of life, than any special *pattern* of subject matter taken in high school. Anything, therefore, which we can do to help obtain a better quality of work in high school will help to secure a better quality of work in college and in all phases of life. The revision of requirements for entrance to college is a move in that direction.

It cannot be known at this time just what revisions in curricular offerings in secondary schools will result. The chances are that very slight changes will be made at any near date in the larger high schools. It begins to appear, however, that quite a number of the smaller schools will make changes in their limited offerings in order better to suit the needs of their own pupils. There was a time when Latin and Greek were constants for every pupil enrolled in a first class high school. That was in a day when there was not such an abundance of subject matter to teach and when social and educational conditions were vastly different from what they are in America today. No one can learn everything no matter how important it may be. Choices must be made and the indications are that considerable number of pupils will decide to take an additional year or two of English instead of the two years of formerly required ancient language. Pupils and teachers argue that a greater facility in the understanding and use of the mother tongue will be of more value to the average citizen in this country in this day than a knowledge of a foreign language. Likewise a considerable number of people feel that science is playing such a large part in modern society that a rather definite knowledge of some phases of this subject is an absolute necessity. Then, coupled with science comes the need for a better understanding of mathematical principles and practices. These and other considerations apparently will make it seem necessary to permit pupils to go further and deeper into such fields as science, mathematics and the like. Since there is a definite limit placed on the amount of subject matter any one pupil can study and assimilate in four years in high school these urgent needs may push ancient languages, and even modern foreign languages, further from the center of the high school curriculum. If this should happen, the loss to a few very worthy pupils will have to be looked upon as compensated for by the larger good to a much larger number of teen age girls and boys. Those who need and want the foreign language and who have to omit it in high school will find it necessary to give

this subject an important place in their college programs.

Indications on every hand are that educational facilities of some sort must be provided for all youth until they reach manhood and womanhood If we should continue to force the heterogeneous multitude to take the traditional subjects specially selected and organized for the select few who formerly found it possible to enroll in secondary schools, the chances are that we should cause many pupils to drop out of school before their time, with a probable increase in the number sent to reform schools and later to prisons.

It is believed that the changed entrance requirements will provide for at least a little further progress in each of the following accomplishments:

1. More harmonious cooperation between secondary schools and colleges for the good of the students each is called on to serve.
2. Opportunity for some pupils to pursue for three and four years in high school some of the subjects in which they have special interest and talent.
3. Special consideration for those pupils who seemingly have blind spots for a particular subject.
4. The development of better attitudes and the formation of habits of success instead of failure.
5. The provision of opportunity for choices, thus making it possible for teachers to insist on better work in the courses taken.
6. The presentation of a situation that will stimulate and develop the special interests and abilities of boys and girls to a little greater degree than is now possible.

RUBBER AND ATOM DISCOVERIES WIN GOLD MEDALS FOR NIEUWLAND AND ANDERSON

Discoveries of synthetic rubber and a new fundamental unit of matter won the two gold medals of the American Institute presented Feb. 7 to Father Julius A. Nieuwland of Notre Dame and Dr. Carl D. Anderson of California Institute of Technology.

Promising to compete in price with natural rubber and superior for some special uses, Father Nieuwland's synthetic rubber, chemically produced from acetylene, was developed by du Pont chemists and marketed under the name Duprene.

The positron discovered by Dr. Anderson, one of Dr. R. A. Millikan's associates, is the positive electron. It is considered one of the three fundamental entities of the universe. Its discovery toppled the old idea that protons and negative electrons alone are the ultimate stuff of atoms.

LIMESTONE: A SIXTH GRADE UNIT*

By Helen Dolman

Michigan State Normal College, Ypsilanti, Michigan

Limestone challenges the imagination. Whether it be a block of marble, wrought through the ages from calcium carbonate, deposited by prehistoric animals, then changed by that strange, immutable force known as crystallization, to shining stone; or glittering stalactites and stalagmites weaving fantastic figures through countless caverns; or chalk from those gaunt cliffs that flank the English channel, like white sentinels gleaming in the sun; or smooth lithographic limestone and clear iceland spar; all have their origin buried in the past but written far more plainly in their structure than words can tell.

Because it is found everywhere in so many different forms, calcium carbonate is one of our most common minerals. A world without it would be so changed that we would not even know ourselves.

So I offer no explanation for the selection of this unit beyond its universality, the teacher's interest and the children's response to that interest.

In the beginning, the outline for content was prepared by Dr. Sherzer and through the years it has been taught and modified, we have found it worth while in its results. It is teacher motivated, but once initiated it is accepted by the children with enthusiasm. Each year they lead into new phases not planned by the teacher.

The approach varies from time to time. Sometimes, a child brings a fossil to school and asks questions about it. One year the social science class was studying cathedrals. The white marble arabesques of Milan stimulated an interest in the origin of such beautiful stone, and led to further study of limestone. Once an aquarium needing snails started a discussion of mollusks.

This year the unit was introduced by way of a smaller unit on clams. A great many children had been to the lake and told of tracks they had seen in the sand. The teacher had gathered enough clams so that all of the children could observe them during the introductory lesson. During the discussion which

* Presented at the Elementary Science Section of the Central Association of Science and Mathematics Teachers held in Indianapolis, Indiana, November 30, 1934.

followed, many questions were raised. Some of these were:

Where are clams found?
How do clams move?
How do clams open and close?
Do clams live in deep or shallow water?
How do clams eat?
How do clams breathe?
Do clams have eyes?
What is the difference in clam and snail tracks?
Do clams lay eggs or are they live bearing?
Is there any way to tell the sex of a clam?
How can you tell how old a clam is?
What makes the shell hard?
How are pearls made?

Later these questions were organized in the following outline made by the children:

I. Shell
    Outside
    Inside
II. Soft body
III. Habits
    How he moves
    How he eats
    How he breathes
    How he reproduces
IV. Pearls

Suggestions were made by the children as to how to find the answers to the questions and it was decided to first answer as many as they could by observing the live clams. During two half-hour periods they found the answers to most of the original questions.

They recorded what they learned by drawing the clam, labelling the anterior and posterior ends, the foot, hinge and siphons. The siphons had been discovered as they watched the live clams in glass jars of water. When a clam was picked up water shot out of the excurrent siphon. There was much discussion as to the reason for the two holes, which was helped along by the teacher dropping powdered carmine in the water near the siphons. When the red stream moved toward the incurrent siphon and came out the excurrent siphon, the children were puzzled. Their first guess had been that the opening was a mouth. So the teacher had to help them by drawing a diagram of the inside of a clam on the board.

When the same questions arose last year, the children insisted upon a dissection but this year's group was satisfied with a picture.

As a result of all of the contributions by teacher and pupils, considerable knowledge of clams was gained. Some of this information was recorded by the children as follows:

The clam has a foot with which he walks.
He uses muscles to keep his shell shut.
His foot is at his anterior end. He walks on his head.
There are two holes at the posterior end called siphons.
His mouth is in his foot.
A clam has gills. He breathes like a fish.
There are many different kinds of clams.
Many clams live in the shallow water of lakes.

The question about pearls was answered by reading in the references. As no reading material on the children's level was available on the reproduction of clams, the teacher told them the story of the life of a clam. The parasitic stage was particularly interesting to them.

Following the study of the live clam, the children examined the shell, noticing the difference in the inside and outside layers. They were given dilute hydrochloric acid with which to test the different parts of the shell. They discovered that the inside or mother of pearl layer "fizzed" when a drop of acid was placed on it but that the brown outside layer did not.

The children found a white deposit on the posterior end of the shell, which reacted to acid. They decided that it was something growing on the shell and since it looked green after being tested, they thought it might be a plant. They were told that they were right.

Someone wanted to know what would happen if a shell were covered with acid, so he was allowed to try it. The next day the results were examined and more questions arose as to what made the shell hard before the acid was put on, and why the acid made it soft.

Some years the teacher has given them pieces of the deposit from the teakettle, to test. They call this lime and it always takes a great deal of explanation to clear up the misnomer.

This time they were simply told that the "fizzing" was due to the chemical reaction of acid with $CaCO_3$, sometimes inaccurately called lime, but more properly lime carbonate or calcium carbonate. They seemed to understand the insoluble form which they could see, but when the question came up as to where the clam got it, the discussion raised more questions:

1. If there is lime in the water why doesn't it poison us?
2. Is mined lime different from lime in the water?

3. Is there more than one kind of lime?
4. Why doesn't the calcium carbonate stay at the bottom of the water?

These questions introduced the unit on limestone. Before they were taken up, hectographed test sheets over the clam were given to summarize and clinch the knowledge gained.

In a laboratory period the children tested various substances, including chalk, lime and ordinary limestone. They discovered and discussed the difference between the reaction of lime and chalk, although they looked alike. They read all that we could find on their reading level, to help answer the other questions. All of their ideas were brought to a class discussion where with the help of the teacher they arrived at the correct conclusion concerning soluble lime in water and insoluble calcium carbonate.

The next step in the unit was to give the children pieces of coquina rock, that shell conglomerate from the coast of Florida that shows so plainly how shells may become cemented together to form a rock. Once when I was presenting coquina a child who had lived in Florida, said "Coquinas are little clams. The people gather them for soup." Looking up the word I found it to be Spanish for "shell-fish." So I am continually learning from the children I teach.

One of the children had visited the Bok tower and told just how it looked. We wondered why the whole tower wasn't made of coquina and decided that it would crumble more easily than marble. They were told about the old fort at St. Augustine which is made of coquina, and how it has weathered.

Commenting upon how this rock might have been made and what would have happened to it if it had remained under pressure for thousands of years, the children said that it might have made fossils. Someone brought a piece of fossil coral the next time we met and we were off on our fossil quest. One question "Why do not all fossils look like clams?" was partially answered by reading a story "A Tale of Trilobites" from the *Nature Magazine*.

As the names of the common fossil groups, brachiopods, gastropods, crinoids and coral came up in the story, they were written on the board and specimens shown the class. At the end of the story, hectographed pictures of several common ones of each group were given out and each child labelled his own key. They all had an opportunity to handle the specimens and had little difficulty in recognizing them.

Of course the purpose of all of this was to prepare for a fossil hunt. The school stands upon a geological kame and not more than a hundred yards from the playground, gravel has been removed from the hillside, leaving exposed a veritable gold mine of glacial deposit, rich in brachiopods, coral and crinoids. Although numerous groups of students have delved and dug in the same spot, thirty children in one half-hour found enough fossils to keep them busy for two days, classifying and mounting.

That brings us up to date in our unit. Next week we plan to answer a question asked by one child, "Are stalactites calcium carbonate?" by giving each child a piece of a stalactite to test. They will probably notice that it is in concentric rings. We have some whole stalactites to show how they were formed as water dripped down from the roof of the cave. The children will understand because they have learned that soluble lime in the water combines with carbon dioxide in the air as the water evaporates to form insoluble calcium carbonate. They can see how it would form the circles as it dripped.

They will also be given pieces of stalagmite for comparison. These show very plainly the layers due to the water spreading out as it dropped to the floor of the cave. They usually notice the similarity to the teakettle deposit.

Slides showing the interior of limestone caves will be used to illustrate the formation of these interesting structures. The teacher visited Luray Caverns last summer and experienced a real thrill in seeing in stone the slides she had been showing for several years.

If interest warrants it, other forms of limestone will be studied. Chalk, as one similar in its formation to fossiliferous limestone, and its fresh water counterpart, marl, always appeal to children.

To make the origin of chalk more real to children, a story is prepared for them to read, which relates an experience in the English Channel, when both the cliffs of Calais and Dover were visible at once.

Last year our English janitor contributed to the interest by telling of the chalk quarries in his home shire. He further enlightened us by telling of one of the uses made of chalk in rural England. The housewives keep a cake of it with which to whiten their hearths and door stones. They wet it and rub it over the stones, much as we use Bon Ami. So we may go on, to the

crystalline forms of calcite and marble, or, interest waning we may make cement by heating limestone. Some years we follow this by making concrete and discovering by experimenting, the best proportions to use. All of which may be summarized by an exhibit of ways in which limestone is useful to man or by an assembly program to share experiences with other children. So many and diverse are the ways in which this has developed in the past that I can not tell where we will end. But I hope to have accomplished these outcomes:

1. Appreciation of the contributions of past ages to the physical environment in which the child lives.
2. Knowledge of the origin of limestone.
3. Knowledge of the importance to man of one common mineral, calcium carbonate.
4. Appreciation of the beauty of the forms of an inorganic substance.
5. Scientific attitudes of cause and effect relationships, of careful and accurate observation, and basing judgment on fact.
6. Increased skill in handling testing materials.
7. Increased desire to investigate their environment and to interpret what they do find.

The materials needed for this unit are easily obtained in almost any part of the United States. Either clams or snails may be used in the introductory unit.

Coquina might be obtained by exchanging with some school in Florida.

Fossil bearing limestones are common while marble scraps may be picked up around buildings and monument works.

At Luray Caverns pieces of stalactite were being sold as were colored pictures of the various formations in the caves. Perhaps the same would be true of Mammoth Cave, Carlsbad and other caverns. There are dozens of caves in Kentucky and Virginia.

The Ward Natural History Company of Rochester, N. Y., sells minerals. But they are high priced and a little scouting in a neighborhood usually will reveal more material than one needs.

The hydrochloric acid used is one part concentrated muriatic acid and four parts water. It is put into small bottles with pipette stoppers so that a drop may be easily used without danger of spilling. The test for calcium carbonate is one drop of cold dilute hydrochloric acid placed on the solid lump. If it effervesces, calcium carbonate is present.

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BRAZILIAN "MAN-EATING" FISH ADDED TO SMITHSONIAN COLLECTIONS

Specimens of the ferocious "man-eating" fish, the piranha, from tributaries of the Amazon river have been added to the scientific collections of the Smithsonian Institution, as part of the scholarly booty brought home by B. A. Krukoff, who recently returned from an expedition into the interior of Brazil. A number of the very rare freshwater species of flying fish were also deposited with the Institution by Mr. Krukoff.

The piranhas are notorious for their ferocity in attacking anything that moves in the water. They are not large fish, seldom reaching a length of over 16 inches, but they have powerful jaws and razor-sharp teeth, which are credited with being able to bite through wire. Natives and whites alike dread them, and carefully avoid getting into waters where they are known to exist. Fortunately for the human inhabitants of the Amazon region, their distribution is relatively limited.

ADVENTURES IN LANDSCAPING VIA THE SHOE BOX

By Elizabeth Stoughton Rawls

Shortridge High School, Indianapolis, Indiana

During the Thanksgiving vacation of 1928, we moved into our well equipped new Shortridge High School. Picture a severely plain three story red brick building a block long and half as wide. It is long, low and factory-like, unattractive except at the entrance, for there had been little money for frills. A school board ruling against having ivy on walls prevented obscuring the prosaic architecture with vines, but the park board helped landscape the outside in a pleasing way, with an interesting and artistic assortment of evergreens, shrubs and trees.

This school, which houses some 3,500 high school students, completely enclosed a desolate, ugly central court 167 by 108 feet. The builders had left the great cement supports exposed at the surface, like colossal checkers all the way round. Small checkered window panes made the effect still worse. Gravel and cement debris from the foundations had been dumped and spread over the ground to a depth, in some places, of more than two feet. Two center drains and three light wells at the corners were the only breaks in the monotony. This unsightly view was the outlook for practically half of the rooms of the school—a forlorn and desolate sight. Students and teachers alike felt as if they were shut up in a prison, facing a prison courtyard; and this tended to produce a prison-like reaction.

We endured it like that for a year and a half, hoping that the school or park authorities could obtain money enough to remedy the situation. Then we went to work overselves.

In three years time, by united action, our school changed that eye-sore of a court into a thing of beauty—a Botanic garden demonstrating the principles of good landscaping, with seasonal succession of color in flower, fruit and foliage; as well as the really wonderful power of active cooperation on an all school project. It is now one of the chief centers of charm and interest in the school. The money for it was raised by voluntary pupil contributions of five cents a month to the school Fine Arts Association. Soil, seeds, plants, tools, toads, fish, etc., and much hard work were donated by students, teachers, janitors and friends of the school.

It is still incomplete and the upkeep is far from perfect. Much remains to be done. But it is far enough along, this year, to be fulfilling a real service to the school and to be starting on its service to the community. Perhaps a few scattered comments about it will make the situation clearer.

In the fall the dean of girls remarked, "It seems to me the colors in the court make it as lovely as a painted picture." This spring one of our girls said, "I've read all my life of crocuses coming up through the grass, but I never saw them before. They're charming. Everybody's talking about them." Also during crocus time, a lad of the "hard boiled" type was discussing his program with his home-room teacher in the office one day, when he interrupted with, "Not to change the subject or anything, but have you looked out that window? Isn't that pretty?"

This from an office clerk, "I was sorry to see the tulips fade, but as one thing stops blooming something else just as lovely keeps coming out." From the president of a city garden club, "There's such an atmosphere of restfulness about it." From a teacher, "For those of us who'll never be able to afford a landscaped estate, watching our court is almost as good as owning a lovely garden."

One day in June, a pupil examining the flowers by the pool said, "I'm out here copying a list of plants that have been in bloom around the pool. They've been awfully pretty. Mother is starting a rock garden and thought she'd like to know what plants would be good to use." A box of cuttings was sent home with the list, and at last reports all were thriving.

Another teacher more recently remarked, "It seems so natural now to have the court this way, that it's hard to remember back to how dreadful it was at first." Making considerable allowance for local prejudice in our own favor, still our mutual service garden seems to be well under way. To have this much by this date would have been beyond our wildest dreams in March, 1930.

At that time there was no good top soil in the court, nothing but coarse, uneven gravel. There was but one small entrance, and it could be reached only by a devious route through the teachers' lunch room. Any good soil which might be obtained would have to be carried along this inconvenient path, or else dumped out of a hall or lunchroom window. The park and school authorities had definitely decided that they could not afford to undertake the project. There was no money. But

there was intense dissatisfaction with things as they were, and a keen desire for something better.

The botany instructors wished to use the shady corners for growing unusual wild flowers that were constantly being brought in. Yet where would they find suitable soil for them, and how could they get it in if they had it? Someone suggested that perhaps the students who could not donate the wild flowers would be willing to bring in small quantities of good soil.

The head of the biology department finally got things started. During spring vacation, she requested one of the botany teachers who had had landscape training to draw up a plan of what we would like to have, if we could finance it. Immediately after vacation, she herself inaugurated a campaign throughout the school for a shoeboxful of good dirt from every pupil. The faculty rallied round and boosted the movement gallantly. There was a lot of good natured chaffing, and a few jeers and sneers, but the shoeboxfuls began to roll in. Freshmen, sophs, juniors and seniors were pitted against each other to see which could get the largest pile. However it might as well be admitted that the resulting mounds did not loom large in that waste of 167 by 108 feet.

Many youngsters wanted to help but did not wish to carry in the dirt. These contributed ten cents each in class groups, to buy loads of rich loam which were delivered outside of the building. Here the larger boys handled it in relays—shoveling it into bushel baskets, loading it onto lunchroom carts, wheeling it in, hoisting it up on a high window-ledge, dumping it out through a slanting window, shoveling it back into baskets and wheel barrows and hauling it to the desired location—strenuous work, all of it. And woe be unto all concerned if any dirt fell on the floors and got tramped over the building—but you could hardly blame the overworked janitors for that.

In this way, enough soil was obtained for a six inch layer for two wild flower beds, a bushel basketful for the roots of each of the border trees and shrubs desired, and a little was left for along the walls. Our Fine Arts Association had decided to finance the prepared plan to the extent of these border plants, provided the buildings and grounds department would, during the summer, bring in sludge from the sewage disposal plant and establish a lawn in the center.

On May day, the trees and shrubs which could be moved so late in the season, were put in, and the others transplanted the

following October. During the summer, about one fourth of the center was covered with sludge (and great was the smell thereof, assurances to the contrary notwithstanding!) and nothing at all was done about making a lawn. The wildflowers and the few trees, shrubs and annuals grew fairly well but looked somewhat pitiful and lonesome. Nevertheless they gave a tangible evidence of what might be done.

Unstinted praise is due to the organizer and managers of our Fine Arts Association. A year before our new building was completed, our enterprising and farsighted librarian had observed the remarkable results obtained in beautifying a high school building in Cincinnati through such an organization. On her return she started the ball rolling for a similar school-wide association to partly finance the Sellick Art Gallery for the new building. All the pupils who wished contributed five cents a month so that by the time we moved into the new building there was a working capital available for different sorts of art projects.

A landscape architect was called in to check up on, modify and supervise the execution of the plan already begun. Consequently, during the spring vacation of 1931, one year from the making of the first plan, a real transformation was achieved. This included the removal of five inches of gravel; grading, filling in with seven inches of good loam; and installing a ten by twenty foot octagonal pool to replace the farther drain. A four-foot-wide flag walk of Pennsylvania sandstone, enclosed a great octagonal panel of turf and led up to the pool which had a three-tier rock margin. Against the far wall, a center of historic as well as garden interest was developed at the end of the axis from the office windows, along the line of the drain and pool. This was a pergola flanked by lombardy poplars, sheltering a bronze wall-fountain which had been the gift to the school of the class of 1901. On either side of the pool beyond the turf panel, two shrub and perennial beds were constructed with a background of an evergreen hedge. The hedge was planned to screen out the unsightly windows at the end of the court, without shading them, but as yet the evergreen growth seems painfully slow and the screen effect is still a thing of the future.

Since our big spring drive of 1931, many perennials, bulbs, annuals, ferns and wild flowers have been added, replacements made, and most of the species temporarily labelled. To do this was not quite so simple as it sounds in review, for our enclosed

area presented a number of difficulties. The light wells at the corners cause continuous drying air currents (an interesting study for the physiography classes). The underlying gravel drains the soil too fast. There can be but a minimum of care during the summer. Trees and shrubs must not cut off light from schoolroom windows and must be located and limited accordingly. The ugly checkered walls are still hideously conspicuous, because ivies are allowed only in the corners where there are no ventilators. Euonymus radicans is the only clinging vine permitted, and none of ours appear to be enjoying life, while those planted in the direct sun refused to survive at all.

Maintaining color and balance in this enclosed garden with its axis running east and west has required constant vigilance. The north side is unusually hot, due to the direct sunlight and the heat reflected from the walls and windows of the building. The south side is always shaded, and even near the center the shade is noticeable and has disconcerting effects. During the early spring our several hundred crocus bulbs in the central grass plot, come out in four rather conspicuous tiers, at intervals of some five days apart. The daffodils and tulips in the evergreen beds show the same succession. This gives only a short time for the total mass effect but prolongs the blooming season and is an interesting demonstration of the influence of sunlight on flowering.

As many species and varieties of plants as possible have been chosen to give good color during spring and fall, the times when school is in session. On our grounds inside and out, there are now seventeen different kinds of evergreens, fourteen types of trees, fifty shrubs, eighty perennials, seventy wild flowers and ferns, eleven vines and several annuals. But the development of a Botanic garden on a small scale has been kept subordinated to the need of a pleasing mass effect.

The most satisfactory color displays through the school year have been the following. In early fall, the silver lace vine, clematis, rose of Sharon, hydrangea p. g., plumbago, August lily, ageratum, early cosmos, spider-plant, snapdragon, marigold, turtlehead, zinnia, verbena and sweet alyssum. Late fall adds chrysanthemums, late cosmos and New England, heart-leaved, and tataricus asters; with foliage tints of red from barberry, red chokeberry, sumachs, highbush and Japanese bush cranberries, cotoneaster divaricata, sourwood and sassafras; and splashes of yellow from redbud, spicebush, kerria, wild

hydrangea, pussy willow, and with us, ginnala maple.

Mid-winter is still pretty meager. The evergreens are small, and the yucca, mahonia and euonymus rather poor. The several types of winter berries and shrubs with colored twigs seem rather lost in space. However the ground covers of myrtle, English Ivy and moneywort are slowly becoming more adequate.

Early April is gay with hundreds of crocus bulbs (may I recommend mammoth yellow for length and abundance of bloom?), a number of hyacinths and daffodils, many wildflowers; and dwarf iris and arabis near the pool. Late April and the first of May is tulip time. Murillo, Inglescombe yellow, Pride of Haarlem and Princess Elizabeth have been splendid. In the shade, buttercups, kerria, wild sweet William, wild geranium and forgetmenot-anchusa blossom; while around the pool phlox subulata, snow in summer, veronica, ajuga and soapwort come out in succession.

During mid-May the color effects come from the hugonis rose, chokeberry, weigela, highbush cranberry, Japanese snowball, iris, peonies, pinks and painted daisies. The last of the school year brings out the mock orange, late peonies and iris, and delphinium; in the shade, the Japanese bush cranberry, columbines, forgetmenot, annual and perennial cornflowers; while maiden pinks and waterlilies make the pool attractive.

The pool, the birds that nest with us or visit us during migration, and the insects (yes, there are some, worse luck) are of special interest to the Zoology students. The garden serves as a wonderfully helpful field laboratory for the Botany classes. It is hoped also that this demonstration garden may do much silent teaching for the many pupils who do not have the opportunity to study Botany formally. We believe that after living with and observing the succession in the garden during their four high school years, these young people should be better able to make attractive gardens about their own homes.

Because of its inaccessibility and the fact that classrooms open off of it, the court cannot be used as a playground for crowds of pupils. However they may go there before or after school, or in twos or threes during the lunch hours if they keep their voices low. On pretty days after lunch, there is a quiet, orderly promenade out around the walk, a few minutes stay near the pool, pergola or wildflower corners, and back into the lunchroom.

The old prison-court attitude when all sorts of things might be thrown out of the windows from erasers and chalk to paper darts and ink bottles, have given place to a pride in it, a desire to have their pictures taken in it, to show it to their parents, friends and small brothers and sisters. For it is theirs. They have contributed to it, worked for and in it, and rightfully feel the glow of part ownership.

UNITED STATES EDUCATIONAL DIRECTORY FOR 1935

Nearly fifty per cent of all institutions of higher learning in the United States are located in 10 States, the Federal Office of Education announced in its 1935 Educational Directory, just off the press. Of 1,662 institutions included in the new college guide, 783 are found in the following States: New York, 100; California, 99; Illinois, 99; Pennsylvania, 97; Texas, 86; Iowa, 64; Ohio, 64; Massachusetts, 62; Missouri, 60, North Carolina, 52.

Part III of the 1935 Educational Directory lists colleges and universities, professional schools, teachers colleges, normal schools, junior colleges, and Negro colleges. Pennsylvania, New York, and Ohio lead other States in number of colleges and universities with 51, 45, and 45 respectively. Illinois, New York, and Pennsylvania have more professional schools than any other States.

There are 158 teachers colleges in our country. Of this number, 13 may be found in Pennsylvania, 10 in Wisconsin, and 10 in Massachusetts. New York also leads in number of normal schools, while California, Texas, and Iowa report more junior colleges than any of the other States. Most of the Negro colleges and universities may be found in Texas, North Carolina, Georgia and South Carolina.

Approximately one third of all institutions of higher learning in the United States are controlled by the Protestant denominations. About one fourth are State-controlled, one fourth privately-controlled, about one ninth under Roman Catholic denominational control, and one ninth under district or city control.

There are 229 colleges for men in the United States, 270 colleges for women, and 1,163 coeducational institutions in the United States, the Federal Office of Education announces. Of this 1,622 total, 107 are Negro institutions of higher learning.

In addition to the college section of the 1935 Educational Directory there are three other sections published by the Federal Office of Education as follows:

Part I—State and County School Offices throughout the United States, the most complete national guide list of State school officials and county school superintendents available. (In Press)

Part II—City School Officers, listing names and addresses of city school superintendents, supervising principals, business managers, research directors, and superintendents of Catholic parochial schools. (Price 5 cents)

Part IV—Educational Associations and Directories, a 47-page list of national and sectional associations, educational foundations and boards, Jewish educational organizations, church educational boards, international educational associations and foundations, State library associations and commissions, National Congress of Parents and Teachers, and other educational directories available from many sources. (Price 5 cents)

Order Part III, Colleges and Universities (Price 5 cents) or other parts of the 1935 Educational Directory from the Superintendent of Documents, Government Printing Office, Washington, D. C.

THE PROTON EXCHANGE CONCEPT OF ACIDITY

By Ernest W. Bowerman

Assistant in Chemistry, The Ohio State University, Columbus, Ohio

Acids-Bases and the Ionic Theory: The Arrhenius ionization theory of electrolytes offered the first logical explanation for the properties common to all acids. The observations that all acids were electrolytes, together with the fact that the ionization of acids always occurred in such a way as to produce hydrogen ions, indicated that an acid was a hydrogen compound which in solution gave hydrogen ions. This customary definition attributes to the hydrogen ion all the properties characteristic of acids such as sour taste, effect on indicators, catalytic effect on certain reactions and the ability to neutralize bases. Since it is assumed that as a rule the ionization of an electrolyte is incomplete and results in an equilibrium between the ions and the undissociated molecules, then that acid should be strongest which, for a given weight of ionizable hydrogen, produces the most hydrogen ions in its solution. Factors affecting the degree of ionization such as the nature of the solvent, the nature of the acid and the degree of dilution also affect the strength of the acid. Accordingly, hydrogen chloride dissolved in a highly polar solvent, such as water, is a very strong acid. However, if hydrogen chloride is dissolved in a non-polar solvent such as benzene, the acid character should be lost because no ionization takes place. Acetic acid is said to be a weak acid because it fails to dissociate to any great extent when in solution in a polar solvent.

Similarly, the ionization theory accounts for basic properties by attributing to the hydroxyl ion all the common characteristics of bases. The ionization of a base, like that of an acid, is a reversible reaction leading to an equilibrium, and the strength of bases is determined by the same factors which affect the strength of acids, namely: the nature of the base, the nature of the solvent and the degree of dilution.

Water has played an important role in the ionic concept of acidity, for it has not only served as a solvent for both acids and bases, but also as a medium for all common acid-base equilibria. Water is a common reactant of hydrolysis as well as a common product of all neutralizations. The fact that water is itself very slightly ionized, furnishing both hydrogen and hy-

droxyl ions, seemingly indicates that it is essential to any concept of acidity.

The Concept of Acidity Cannot be Limited to Aqueous-Solutions: Water is not the only polar solvent which will cause dissociation of acids and bases. Liquid ammonia, hydrogen fluoride, hydrogen cyanide, as well as other solvents having high dielectric constants are about as effective as water itself. Many organic solvents such as alcohols, acids and amines also dissociate acids and bases and serve as reaction media for acid-base equilibria. One of the earliest objections to the idea that basic properties could only be associated with hydroxyl ions was demonstrated by Goldschmidt in 1896 when he found that such substances as aniline would neutralize acids, the reaction taking place in non-aqueous solvents where the formation of hydroxyl ions was out of the question. He regarded a substance as a base if it showed a tendency to add hydrogen ion to form a positive ion. Following this idea aniline would act as a base as represented by the equation

$$\underset{\text{(base)}}{C_6H_5NH_2} + \underset{\text{(hydrogen ion)}}{H^+} \rightleftarrows \underset{\text{(positive ion)}}{C_6H_5NH_3^+}$$

Further evidence that basic properties are not limited to the hydroxyl ion has been demonstrated by Franklin. He has shown that there can be as many analogs of the hydroxyl ion as there are solvents of the type HX, where X can be almost any non-metallic radicle such as: OH^-, NH_2^-, SH^-, HSO_4^-, Cl^-, F^-, $C_2H_3O_2^-$, etc. If liquid ammonia is the solvent it is the amide anion, NH_2^-, which makes the solution basic. In this case the amide anion can be furnished by any soluble amide, such as KNH_2. Similarly, the acetate ion, furnished by any metallic acetate soluble in anhydrous acetic acid, produces basic properties in this solvent. Neutralizations in the solvents; water, liquid ammonia and acetic acid, using the corresponding bases, are illustrated respectively by the following reactions:

$$HCl + KOH \xrightarrow{\text{water}} KCl + HOH$$

$$HCl + KNH_2 \xrightarrow{\text{ammonia}} KCl + HNH_2$$

$$HCl + KC_2H_3O_2 \xrightarrow{\text{acetic acid}} KCl + HC_2H_3O_2$$

Each of these reactions can be followed by the potentiometric method, and the end of each reaction can be determined by

means of indicators. The idea that potassium acetate can exhibit basic properties is not new, for aqueous solutions of acetates have long been used as buffers, the purpose of these solutions being to neutralize excess acid and thus keep the hydrogen ion concentration at a definite value. On inspecting the above reactions it will be found that each of the basic constituents (the $\overline{OH}$, $N\overline{H_2}$ and $^-C_2H_3O_2$ ions) has one common property—the ability to add on a hydrogen ion forming a substance one unit more positive than the basic particle itself. This corresponds exactly to the Goldschmidt definition of a base.

The major objection to the Arrhenius idea of "acidity" arises from the fact that modern evidence indicates that there is no solvent in which any appreciable concentration of free hydrogen ions, H^+, (free protons) is likely to exist. Because of its infinitesimal size in relation to its charge, the proton, H^+, will always be found attached to some other atom or group of atoms. Thus in liquid ammonia, the proton always exists in a solvated form such as $H^+(NH_3)$ or NH_4^+, the ammonium ion. In fact any ammonium salt when dissolved in liquid ammonia exhibits acid properties, e.g., NH_4Cl is an acid in this solvent. Hydrogen chloride when dissolved in liquid ammonia reacts with the solvent at once to form the solvated ion, NH_4^+, which in turn gives the solution its acid character. In water the proton is also solvated and exists as the hydronium ion, $H^+(H_2O)$ or H_3O^+. For example, when dry hydrogen chloride is passed into water a vigorous reaction occurs which runs practically to completion according to the following reaction:

$$HCl + H_2O \rightleftarrows H_3O^+ + Cl^-$$

Thus it is not really the free hydrogen ion but rather the solvated proton, the hydronium ion, which is the carrier of the characteristic acid properties in aqueous solutions. Similarly in in other polar solvents, the proton exists in the solvated form, which can be termed the characteristic acid-cation of the solvent. The acid-cations of the solvents: water, liquid ammonia, acetic acid and hydrogen flouride are respectively H_3O^+, NH_4^+, $H_2C_2H_3O_2^+$ and H_2F^+. Since the free proton cannot exist in solution in polar solvents, acidity cannot be entirely explained on the basis of the old ionic theory.

The dissociation theory of acidity also completely fails to offer an explanation for acid-base equilibria in non-polar or

non-ionizing solvents. It is common contention that anhydrous hydrogen chloride is not an acid when dissolved in benzene because such a solution contains no hydrogen ions. However, modern experimental evidence shows that acids dissolved in non-polar solvents will catalyze such reactions as organic rearrangements which until recent years have been thought to be catalized only by hydrogen ions. The rearrangement of hydrazobenzene is accelerated by a benzene solution of hydrogen chloride just as effectively as by aqueous hydrogen chloride. Evidently free hydrogen ion is not the catalyst for such reactions for it certainly does not exist in non-polar solvents. The acid itself must be the catalyst. Also acids dissolved in benzene can be used to neutralize bases in much the same manner as in water solutions. Thus a benzene solution of aniline will react with a benzene solution of hydrogen chloride, the reaction being

$$C_6H_5NH_2 + HCl \xrightarrow{\text{benzene}} (C_6H_5NH_3)^+Cl^-$$

Here the solvent, benzene, is entirely inert, serving only as a solvent medium for the reacting substances. Another example of an acid-base equilibrium in benzene is offered by the reaction of picric acid and aniline, represented by the following equation:

$$(NO_2)_3C_6H_2OH + C_6H_5NH_2 \rightleftarrows [(NO_2)_3C_6H_2O^-][C_6H_5NH_3^+]$$

It happens that aniline picrate is colored so that the extent of the reaction can be studied colorimetrically in the same manner that acid-base equilibria are studied in water solutions. Numerous reactions of this type have been studied by such investigators as Hantzsch and Brönsted, who have shown that the old ionic concept of acidity cannot account for acid-base equilibria in the non-ionizing type of solvent.

The Present Proposal: Realizing the need for a definition of acidity which would explain acid-base equilibria in both the polar and non-polar type of solvents, J. N. Brönsted and T. M. Lowry, working independently, offered a simple definition in 1923. They defined an acid as any molecule or radicle that is capable of releasing a proton, and a base as any molecule or radicle that will accept a proton. The idea is expressed by the scheme

$$\underset{\text{(acid)}}{A} \rightleftarrows \underset{\text{(base)}}{B} + \underset{\text{(proton)}}{H^+} \qquad (1)$$

The charge on A and B can be either positive, negative or neutral, the only rule being that A must be one unit more positive than B. This definition of an acid and a base as represented by scheme (1) brings out the close relation between these two classes of substances, for a base is necessarily formed whenever a substance functions as an acid, releasing protons, and conversely an acid has always to be formed when a base takes up a proton. An acid and a base related to each other as in scheme (1) are termed conjugate acid and base.

The significance of the Brönsted point of view is best seen from a few examples. Thus for acetic acid:

$$\underset{\text{(acid)}}{HC_2H_3O_2^-} \rightleftharpoons \underset{\text{(base)}}{C_2H_3O_2^-} + \underset{\text{(proton)}}{H^+}$$

Here the base is the acetate ion, which has a fairly strong tendency to combine with a proton to form acetic acid. Acetic acid is the conjugate acid of the acetate ion which in this case is the base. Ammonia is a base as indicated by

$$\underset{\text{(base)}}{NH_3} + \underset{\text{(proton)}}{H^+} \rightleftharpoons \underset{\text{(acid)}}{NH_4^+}$$

In this case the ammonium cation is the conjugate acid of the base ammonia. The conjugate base of hydrochloric acid is the very weakly basic chloride anion which gives hydrogen chloride its very strong tendency to give protons.

$$\underset{\text{(acid)}}{HCl} \rightleftharpoons \underset{\text{(proton)}}{H^+} + \underset{\text{(base)}}{Cl^-}$$

Similar schemes can be written for all acids. The polybasic acids offer an interesting situation where a radicle can function as an acid in one conjugate system and as a base in another. Phosphoric acid has a fairly strong tendency to release a proton forming the $H_2PO_4^-$ ion as its conjugate base:

$$\underset{\text{(acid)}}{H_3PO_4} \rightleftharpoons \underset{\text{(base)}}{H_2PO_4^-} + \underset{\text{(proton)}}{H^+}$$

But the $H_2PO_4^-$ ion can also act as an acid for it can release a proton as indicated by

$$\underset{\text{(acid)}}{H_2PO_4^-} \rightleftharpoons \underset{\text{(base)}}{HPO_4^=} + \underset{\text{(proton)}}{H^+}$$

The tendency for the $H_2PO_4^=$ to release a proton is far less than the ability of phosphoric acid to release a proton. Going still

further, $HPO_4^=$ can function as a weak acid for it exhibits a small tendency to give a proton as represented by

$$\underset{\text{(acid)}}{HPO_4^=} \rightleftharpoons \underset{\text{(base)}}{PO_4^{\equiv}} + \underset{\text{(proton)}}{H^+}$$

A similar but slightly different situation is exhibited by water. The Brönsted definition explains the amphoteric character of water, for it can function as an acid releasing a proton forming the hydroxyl ion which is the conjugate base of water, thus

$$\underset{\text{(acid)}}{H_2O} \rightleftharpoons \underset{\text{(proton)}}{H^+} + \underset{\text{(base)}}{OH^-}$$

On the other hand water can also act as a base combining with a proton, forming the H_3O^+ cation which is a strong acid.

$$\underset{\text{(base)}}{H_2O} + \underset{\text{(proton)}}{H^+} \rightleftharpoons \underset{\text{(acid)}}{H_3O^+}$$

The Fundamental Acid-Base Equilibrium: Actually the reaction represented by scheme (1) can take place only when a base is present to accept the proton, for as indicated previously the simple hydrogen ion or proton is not likely to exist in the presence of other molecules. If the acid A_1 can react with the base B_2 the following step-wise reaction will occur; first the acid A_1 can release a proton with the formation of its conjugate base B_1, thus

$$\underset{(\text{acid}_1)}{A_1} \rightleftharpoons \underset{(\text{base}_1)}{B_1} + \underset{\text{(proton)}}{H^+} \qquad (2)$$

Simultaneously the base B_2 will combine with the proton released by A_1 as indicated by the scheme

$$\underset{(\text{base}_2)}{B_2} + \underset{\text{(proton)}}{H^+} \rightleftharpoons \underset{(\text{acid}_2)}{A_2} \qquad (3)$$

Here A_2 is the conjugate acid of the base B_2. Adding the reactions represented by schemes (2) and (3) results in the scheme,

$$\underset{(\text{acid}_1)}{A_1} + \underset{(\text{base}_2)}{B_2} \rightleftharpoons \underset{(\text{acid}_2)}{A_2} + \underset{(\text{base}_1)}{B_1} \qquad (4)$$

which in the light of the Brönsted idea is the fundamental acid-base equilibrium. On inspecting the reaction it is apparent that two conjugate systems are involved; also it is obvious that the acid-base reaction consists in the transfer of a proton from (acid_1) to (base_2) with the formation of (acid_2) and (base_1).

The products formed are weaker than the original substances—weaker in their tendency to release and accept protons. The equilibrium represented by scheme (4) lends itself immediately to the application of the law of mass action and other principles which apply to equilibria in general.

This concept is best seen through the consideration of a few examples. According to the ionic point of view the fundamental acid-base reaction was a "neutralization" being characterized by the union of hydrogen ion and hydroxyl ion forming water. The new definition accounts for the process of neutralization in the following manner. When dry hydrogen chloride is dissolved in water a reaction takes place as represented by the scheme:

$$\underset{(\text{acid}_1)}{HCl} + \underset{(\text{base}_2)}{H_2O} \rightleftharpoons \underset{(\text{acid}_2)}{H_3O^+} + \underset{(\text{base}_1)}{Cl^-}$$

If now dry potassium hydroxide, consisting of a crystalline ionic lattice of K^+ and OH^- ions, is dissolved in a further quantity of water, the ions remain separated; they may surround themselves with a sheath of water. On pouring these solutions together a reaction takes place which can be represented by the following scheme:

$$\underset{(\text{acid}_1)}{H_3O^+} + Cl^- + K^+ + \underset{(\text{base}_2)}{OH^-} \rightleftharpoons \underset{(\text{acid}_2)}{H_2O} + \underset{(\text{base}_1)}{H_2O} + K^+ + Cl^-$$

On inspecting this reaction it is obvious that water is the only thing formed by chemical reaction in the strict sense, the potassium and chloride ions merely play the part of innocent bystanders and are the only survivors of the reaction. Fundamentally this acid-base reaction is

$$\underset{(\text{acid}_1)}{H_3O^+} + \underset{(\text{base}_2)}{OH^-} \rightleftharpoons \underset{(\text{acid}_2)}{H_2O} + \underset{(\text{base}_1)}{H_2O}$$

One of the merits of the Brönsted theory of acidity is that it does not confine the reaction of an acid with a base to a "neutralization" but rather sets a neutralization as a specific type of acid-base equilibria which has run nearly to completion, with the formation of water. The process of hydrolysis is an acid-base equilibrium and can be explained by the new theory showing that any negative ion which is capable of taking a proton from the hydronium cation can serve as a base in aqueous solutions. The hydrolysis of a salt of an active base and an inactive acid demonstrates the case where an anion functions as a base. When sodium carbonate is dissolved in water the carbonate ion

has the tendency to take a proton from the water molecule establishing the equilibrium

$$\underset{(base_2)}{2Na^+ + CO_3^{=}} + \underset{(acid_1)}{HOH} \rightleftharpoons 2Na^+ + \underset{(base_1)}{OH^-} + \underset{(acid_2)}{HCO_3}$$

The hydrolysis of a salt of an inactive base and an active acid is also accounted for by the new theory of acidity. If ferric chloride is dissolved in water the ferric cations surround themselves with six molecules of water forming the salt, $FeCl_3 \cdot 6H_2O$, which exists in solution as $[Fe(H_2O)_6]^{+++}$ and Cl^- ions. The ferric-hexadydrate ion has a tendency to release a proton from one of its coordinated water molecules which is in turn taken up by the molecules of the solvent forming the hydronium ion. The acid-base equilibrium of such a hydrolysis is represented by the scheme

$$\underset{(acid_1)}{Fe(H_2O)_6^{+++}} + \underset{(base_2)}{HOH} \rightleftharpoons \underset{(base_1)}{Fe(H_2O)_5(OH)^{++}} + \underset{(acid_2)}{H_3O^+}$$

Although one naturally turns for illustrations to the familiar field of aqueous solutions, Brönsted's definition of acidity applies equally well to solutions in any polar solvent. Hydrochloric acid dissolves in liquid ammonia as represented by

$$\underset{(acid_1)}{HCl} + \underset{(base_2)}{NH_3} \rightleftharpoons \underset{(acid_2)}{NH_4^+} + \underset{(base_1)}{Cl^-}$$

Little wonder then that NH_4Cl and HCl give rise to the same acid when dissolved in liquid ammonia. The amide ion (NH_2^-) which is furnished by any soluble amide, such as KNH_2, when dissolved in liquid ammonia acts as a strong base and can neutralize the acid character of the ammonium ion. Thus

$$\underset{(acid_1)}{NH_4^+} + \underset{(base_2)}{NH_2^-} \rightleftharpoons \underset{(acid_2)}{NH_3} + \underset{(base_1)}{NH_3}$$

This reaction is entirely analogous with neutralization of the hydronium ion by hydroxyl ion in water solutions. Similar schemes can be written for acid-basic equilibria in any polar solvent, e.g., HF, $HC_2H_3O_2$,H_2SO_4, alcohols and amines.

Acid-base equilibria in non-polar solvents such as benzene and other hydrocarbons as well as hydrocarbon derivatives are explained equally well by the new idea of acidity. It must be remembered that these solvents are entirely inert in that they do not exhibit acid or basic properties—that is they do not give or accept protons. Such solvents act merely as reaction medium

and take no part in the equilibrium. When hydrochloric acid is dissolved in benzene it is present as HCl molecules and a base must be added in order for it to exhibit acid properties. Aniline is soluble in benzene and will neutralize the hydrochloric acid solution as indicated by the reaction

$$\underset{(\text{acid}_1)}{HCl} + \underset{(\text{base}_2)}{C_6H_5NH_2} \xrightleftharpoons{C_6H_6} \underset{(\text{acid}_2)}{C_6H_5NH_3^+} + \underset{(\text{base}_1)}{Cl^-}$$

In these apparently dissimilar illustrations which have been considered there is one striking thing in common; all consist in the transfer of a proton from a molecule or radicle which has a tendency to release a proton to a molecule or radicle which can accept a proton. Accordingly, the new concept of acid-base equilibria very uniquely characterizes these phenomena as a proton exchange in the same manner that oxidation-reduction reactions are uniquely characterized by electron exchange. The Brönsted theory relates the concept of acids and bases in a more logical manner than does the ionic theory. It attributes acid and basic properties to the molecules of acids and bases themselves and not to their solutions thus offering a definition which is independent of the solvent. Above all, the proton exchange concept of acidity is in harmony with the experimental facts.

NEW METHOD FOR STUDYING ATOMS IN CRYSTALS SPEEDS ANALYSIS OF WEAKNESSES IN STEEL

A simplified and speedy method of studying atom layers in metal crystals, expected to cut markedly the time necessary for crystal structure studies in metallurgy, has been developed by Alden B. Greninger of the Graduate School of Engineering, Harvard University.

The new method is a variation of the classical scheme of the German scientist Max Laue for "fingerprinting" atoms in a crystal by making the atoms diffract X-rays and having them fall on photographic plates in characteristic, spotty patterns. From these X-ray patterns science has been able to tell what type of crystal structure produced them.

Such knowledge is vital for studies of metal weaknesses and, hence, is intimately bound up with problems of strength in such things as railroad rails, armor and boiler plate, and metal automobile chassis frames.

Insteading of making X-rays pass through the crystal, which had to be cut in fairly thin sections in the former Laue method, Mr. Greninger cuts a hole in the photographic plate, passes X-rays through it, lets them fall on the surface of the crystal being studied and finally catches them on the plate as they are diffracted backward.

From the characteristic pattern thus obtained the arrangement of atom layers in the crystal can be calculated with relatively simplicity.

DIOPHANTINE RECREATIONS

By Adrian Struyk

Clifton High School, Clifton, New Jersey

In the paragraphs which follow we shall deal with certain trinomials of the form px^2-qx-t. We shall require that these expressions satisfy two conditions: (1) p, q, and t must be consecutive integers; (2) px^2-qx-t must have linear factors with integral coefficients.

To formulate the matter more precisely, the subject of our discussion is a solution of the following

PROBLEM: Find integers a, m, n, r, s such that

$$(a-1)x^2-ax-(a+1)=(mx+n)(rx-s). \qquad \text{(A)}$$

To determine two or three such sets of integers requires but a few minutes of trial. We quickly find, by taking $a=2, 3, \cdots, 15$, that within this range only three sets exist.

Thus
$$x^2-2x-3=(x+1)(x-3), \qquad (1)$$
$$4x^2-5x-6=(4x+3)(x-2), \qquad (2)$$
$$12x^2-13x-14=(3x+2)(4x-7). \qquad (3)$$

What we desire, however, is a procedure more definite than experiment for determining these numbers.

Let us write the numbers which occur in the factors given above in a tabular form:

	m	n	r	s
(1)	1	1	1	3
(2)	4	3	1	2
(3)	3	2	4	7

Certain simple relations then come to our attention. These are:

$$m_2=r_1+s_1,\ n_2=s_1,\ r_2=m_1,\ s_2=m_1+n_1;$$
$$m_3=r_2+s_2,\ n_3=s_2,\ r_3=m_2,\ s_3=m_2+n_2.$$

Two features make these relations worthy of note: first, the equations that relate (2) to (1) and the equations that relate (3) to (2) are the same in form; second, (2) can be derived from (1), and (3) can be derived from (2).

Is it possible that the relations discovered will enable us to find other sets of integers which satisfy equation (A)? To put the matter to a test we calculate the four numbers m_4, n_4, r_4, s_4 given by the equations

$$m_4 = r_3 + s_3,\ n_4 = s_3,\ r_4 = m_3,\ s_4 = m_3 + n_3.$$

We obtain 11, 7, 3, 5 respectively. Using these numbers we form two binomials, which correspond to the factors in the right-hand member of equation (A). We get $11x+7$ and $3x-5$. The final step is to take the product of these binomials. The product is $33x^2-34x-35$! Exhibiting the result in the form of equation (A) we have

$$33x^2-34x-35=(11x+7)(3x-5). \tag{4}$$

If we repeat the process of the preceding paragraph we find that

$$88x^2-89x-90=(8x+5)(11x-18). \tag{5}$$

As a matter of fact, this procedure does yield, with each repetition, a new set of integers satisfying equation (A). A proof of this will be given. It amounts to proving the following

THEOREM: If the product $(mx+n)(rx-s)$ is of the form $(a-1)x^2-ax-(a+1)$ then the product $([r+s]x+s)(mx-[m+n])$ is of that form.

Consider the identity

$$(mx+n)(rx-s)=mrx^2-(ms-nr)x-ns.$$

We suppose that the numbers mr, $ms-nr$, ns are consecutive integers. Then

$$mr+1=ms-nr=ns-1. \tag{B}$$

Now
$$([r+s]x+s)(mx-[m+n])=$$
$$(mr+ms)x^2-(mr+nr+ns)x-(ms+ns).$$

We proceed to show that $mr+ms$, $mr+nr+ns$, $ms+ns$ are consecutive integers.

From (B) $\qquad ms-nr=ns-1.$

Hence $\qquad ms+1=nr+ns.$

Add mr to both sides:

$$mr+ms+1=mr+nr+ns. \tag{C}$$

From (B), again $\qquad mr+1=ms-nr.$

Hence $\qquad mr+nr=ms-1.$

Add ns to both sides:

$$mr+nr+ns=ms+ns-1. \tag{D}$$

Combining equations (C) and (D):

$$mr+ms+1=mr+nr+ns=ms+ns-1. \tag{E}$$

Equation (E) shows that $mr+ms$, $mr+nr+ns$, $ms+ns$ are consecutive integers. This completes our proof.

We have now established a definite procedure by which it is possible to determine from a given set of integers a, m, n, r, s satisfying equation (A) another set a', m', n', r', s'. This procedure is based upon four simple equations:

$$m'=r+s,\ n'=s,\ r'=m,\ s'=m+n. \tag{F}$$

The value of a' is determined when the product of $m'x+n'$ and $r'x-s'$ is taken. Obviously, then,

$$a'=m's'-n'r'. \tag{G}$$

The determination of the value of a' can be simplified by the use of another relation, which we proceed to derive.

Let us take note of the numbers that have already been found as values for a. Writing them in order, we have

$$2,\ 5,\ 13,\ 34,\ 89.$$

We notice the following:

$$13=3\cdot 5-2,$$
$$34=3\cdot 13-5,$$
$$89=3\cdot 34-13.$$

Let us extend our series of numbers in the obvious way. Evaluating $3\cdot 89-34$ we obtain 233. We now ask, can equation (A) be satisfied if $a=233$? Consider solution (5). To the numbers 8, 5, 11, 18 we apply (F) and get 29, 18, 8, 13. Then (G) gives $a'=233$! Hence

$$232x^2-233x-234=(29x+18)(8x-13). \tag{6}$$

Before deriving the relation exemplified in the preceding paragraph we note the following equations, which are derived directly from (F):

$$m=r',\ n=-(r'-s'),\ r=m'-n',\ s=n'. \tag{H}$$

We also note that equations (B) and (G) relate the members of any single set of integers which satisfy (A).

Let a, m, n, r, s be integers satisfying equation (A). Applying (F) and (G) we find a', m', n', r', s'. To these, also, we apply (F) and (G) obtaining a'', m'', n'', r'', s''. We shall prove that $a''=3a'-a$.

From (G) $a''+a=m''s''-n''r''+ms-nr$.
Using (F) and (H),

$$a''+a=(r'+s')(m'+n')-s'm'+r'n'+(r'-s')(m'-n').$$

Expanding and simplifying:

$$a''+a=2m'r'-m's'+n'r'+2n's'.$$

Add and subtract 2 in the right-hand member. Then

$$a''+a=2(m'r'+1)-(m's'-n'r')+2(n's'-1).$$

According to (B) and (G)

$$m'r'+1=m's'-n'r'=n's'-1=a'.$$

Hence $$a''+a=2a'-a'+2a'=3a'.$$

Therefore $$a''=3a'-a. \qquad \text{(I)}$$

We add one more example to illustrate our final procedure. As we have found, if $a=89$ then $a'=233$, $m'=29$, $n'=18$, $r'=8$, $s'=13$. Using (I), we find $a''=610$. Using (F) we find $m''=21$, $n''=13$, $r''=29$, $s''=47$. By (A), therefore,

$$609x^2-610x-611=(21x+13)(29x-47). \qquad (7)$$

We conclude with an outline of further easily derived results:

(1) For each value of a the number $\sqrt{5a^2-4}$ is an integer.

(2) If $$bx^2-(b+1)x-b=(hx+k)(kx-h), \qquad \text{(J)}$$
and if b, h, k are integers, then $\sqrt{5h^2-4}$ is an integer. Hence, the values of a lead to solutions of equation (J).

(3) For each value of k the number $\sqrt{5k+^24}$ is an integer.

(4) The result in (3) leads to solutions in integers of the equation

$$cx^2-(c-1)x-c=(fx+d)(dx-f). \qquad \text{(K)}$$

IRON METEORITE FOUND IN SOUTH DAKOTA FIELD

An iron-nickel meteorite, measuring 16 inches in its greatest dimension and weighing 195 pounds 11 ounces, has come into the possession of the South Dakota School of Mines. It was found near the town of Norris, Bennett County, by a farmer. He was disking his field when the implement struck a hard obstruction, which on investigation proved to be a large meteorite.

THE ROMANCE OF RESEARCH

By Mason E. Hufford

Indiana University, Bloomington, Indiana

A short time ago there appeared on a menu card in a dining car on one of our best known railroads the following significant statement: "We live in a wonderful age. It has been said that man has made greater advancement in the last hundred years than in all his previous existence. The last century was the greatest period of all time, in material development, in mechanical invention, in scientific discovery, and in the application of natural elements and forces to the uses of man. But the discoveries of the present century indicate that we are moving forward at a pace surpassing all previous records."

We in physics know that in that field alone relatively simple experiments have told us more of the nature and properties of matter during the past two decades than in all time before. Historians have pointed out that the great events of history are its great scientific discoveries. Human progress therefore strides like a giant from peak to peak of the accomplishments of science. Embellishments there are to human advancement like poetry, music, art but the marble upon which these refinements of culture are chiseled is science, that is, the fundamental sciences, mathematics, physics, chemistry, biology.

While there are those among us who see only the flowers of human accomplishment it may be pointed out that back of the flower is the working leaf and stem, sustained by air, water and the chemical compounds of the earth.

Pasteur once said "Science is the soul of prosperity of nations and the living source of all progress. What really leads us forward is a few scientific discoveries and their application."

A little reflection will show that today we live in an age of rich accomplishment, a time when the common man may enjoy an ease and wealth of life which was unknown to monarchs a few decades ago. So much is this true that already warnings have been sounded that danger lurks in luxury and rightly so, for we know that ease encourages idleness and with no serious responsibilities life becomes ruin.

We might therefore have to pause until we can assimilate our new opportunities, till our philosophy catches up, but eventually the way out is not backward but forward, not less science

but more and as our present state of good living has come through science whatever of nobility our human life may reach, it too will be the fruit of the revelations of science.

When we examine the physical means of our advancement we behold a myriad of things—devices which add to our leisure, our comfort, our physical well being and therefore our mental and spiritual progress. Most of the countless array of things can be traced back one by one to their origin in the industrial scientific laboratory which is a factory for the conversion of principles and laws into practical applications.

One of the first of these ventures in the field of applied science was the establishment of the research laboratory of the Bell Telephone Company. This was in 1876. At the outset Alexander Graham Bell and his assistant Thomas Watson constituted the staff. They experimented in transmitting speech with crude apparatus and with considerable difficulty across a thirty foot room. A few years ago at the close of their lives, these same men using the same instruments were able to talk from New York to San Francisco and this with no difficulty as compared to that first experiment. Still later improvements have made it possible to talk from New York to Honolulu and from Arlington to Paris.

In this span of sixty years the Bell Laboratories have grown from two men to 1300 college and university graduates. The maintenance in men and equipment reaches millions of dollars.

The application of two important inventions will show the justification of the research department. In 1900 Dr. Pupin invented the loading coil which is a simple device for avoiding the phase lag due to capacity effects in cable transmission of speech. Coils and capacities have reverse effects on the phase lag between current and voltage so that by this means long distance communication by under sea lines was made possible. The other invention was that of the electron tube repeater introduced in 1915. This device made it possible to use the ordinary short distance equipment tied up in series to telephone across the continent. The same effect accomplished by heavier wires would have cost twenty million dollars a year. During the first nine years of its use the repeater saved, $160,000,000 to say nothing of the value of better service to the public.

A few years ago the Bell Telephone Laboratories definitely set out to produce an alloy which would have greater mag-

netic properties than iron. The result was the new alloy of nickel and iron called permalloy, which gives far greater permeability than iron and makes possible the reproduction of more feeble currents and hence increases long distance communication. Another laboratory research has produced perminvar, by which the energy loss in telephone currents has been reduced to the one hundred thousandth of the waste incurred with the best grades of iron. A seemingly less important research produced a new alloy for use in contact points where electrical currents are broken. However this metal made possible the automatic telephone exchange, the intricate systems of control of elevators in skyscrapers and the almost thinking control systems for operating railway trains. Every success opens up a new region of possibilities. With such a productive research laboratory every possible hint of improvement is snatched up so that competition of companies is entirely eliminated. Of course without wise legislative restraint there is opportunity for monopoly with its possible evils.

There has never been in American history a greater and more sudden awakening to our indifference and dependency and our want of opportunity and profit as that which came with the world war. Almost overnight our manufacturers found themselves confronted with huge orders for war materials without trained men or equipment or methods for filling them. At that time the duPont Company was separating glycerine from its waste acids by a difficult, slow and dangerous process. Men and money were put to work on the problem with the result that the whole process was revolutionized. It was made safer, quicker and a million dollars of waste saved.

For many years dynamite has been the chief explosive used in construction work. Formerly this material was subject to freezing even at moderately low temperatures and great danger and delay accompanied the necessary thawing for use. The duPont research laboratories found that if the glycerine was first polymerized or if certain nitro bodies were added a low freezing point dynamite could be produced. Again a single research in a new method of producing diphenylamine, one of the compounds of smokeless powder, which was evolved when our supply from Europe was cut off, saved the duPont Company more than $400,000 and not a day's time was lost due to the English blockade. This same research has since the war produced enormous profit by its adaptation to the dye industry.

It is an interesting fact that the dye known as turkey red was first produced synthetically by Graebe and Libermann in Germany in 1868. Before that time the compound was made from madder root. In a period of twenty years the saving in the cost of manufacture amounted to twenty millions of dollars. A similar story may be told of synthetic indigo produced by Baeyer at Munich in 1880. Thousands of other dyes and related substances have been discovered during these past seventy years of chemical research. The present health and happiness of people depends largely upon these substances. Indeed the color and therefore the beauty and romance of life as far as that phase of it is humanely controlled goes back to the chemist.

The duPont Company's laboratories before the war comprised 212 men. During the war the number of workers reached a thousand. There are now ten laboratories. More than six million dollars were spent by that company between 1912 and 1918. Since the war this large staff of research workers has been employed in producing new materials to the end that the American dye industry is now independent of Europe. We also have the new products, rayon, artificial leather, synthetic rubber, pyroxylin plastics and solutions, paints, varnishes and many others. It has been estimated by the company that the research staff has saved as much as $82,000,000 by its new methods and new products.

The General Electric Company with its subsidiary companies has been spending twenty-five million dollars a year in research with the result that our country has far outstripped every other in the production of electrical appliances. Coupled with a too aggressive salesmanship the overbuying of these products and others has caused our whole social structure to undergo a most severe strain. The General Electric Company employs 1350 physicists, chemists and engineers in research work. The work of such laboratories elevates the standard of living of people over the whole earth. While the money profit to stock holders is great the benefits to the public are even greater. For example, in the substitution of tungsten metal for carbon filaments in electric lamps, the country has saved $240,000,000 a year in the lower consumption of electrical energy. Other improvements in electrical power and lighting have saved $2,000,000,000 annually. The development of the Coolidge X-ray tube has made possible the whole branch of X-ray diagnosis in medicine.

The gigantic effort of our Government in the Tennessee Valley for the cheaper and wider distribution of electricity is but a research with no intent of profit but the physical betterment of the people. And what nobler undertaking could be attempted than to develop for the whole people a great resource which by gift of Nature belongs to the whole people!

Not only in the making of new things and in the finding of new methods for their production but the increase of profits by the decrease of wastes has been a subject of research for more than fifty years. By means of committees and trade associations for establishing standards, large inroads in the waste of producing too many kinds of the same article have been accomplished. Instead of making 251 kinds of blackboard slate as formerly there are now fifty-two kinds produced. At one time 125 kinds of metal lath were manufactured where now there are twenty-four. Thirteen hundred and fifty kinds of files and rasps have been reduced to 475. The standardization of parts for automobile manufacture has resulted in a saving of $750,000,000 a year.

Other wastes are still more important. The United States Bureau of Mines has shown that the collection and re-use of waste metals would amount to more than a billion dollars a year. In the Westinghouse Company each employee is a research worker in the sense that he may receive a reward for suggesting methods of reducing waste. The company saves about $50,000 a year by this simple arrangement.

In all the large shops the oils used on cutting points of metal working machines are recovered by centrifuging the greasy metal turnings. Second hand rubber in the United States in 1926 amounted to 164,000 tons. From used tin cans tons of iron and tin are recovered. Parenthetically it would be well if the whole of the American tin can dump could be reclaimed. This is an enormous and needless waste. The Western Electric Company reclaims $100,000 a year from metals in the floor sweepings. The reclaimed silver from the film developing tanks at the Hollywood studios amounts to six thousand dollars a month.

Just now there are other enormous wastes which should enlist the attention of research physicists and chemists both in and out of the industrial laboratories. It has been estimated that over $3,000,000,000 a year are wasted in the corrosion of iron and steel. Experiments are already in progress and we

may look forward to the near future when we shall produce a rustless steel. Just now the research laboratories of the copper refineries are determining the physical and chemical properties of the metal tellurium. This metal is a waste product in the process of refining copper. There seems no ready use to which tellurium can be put.

It would seem also that the molten glasslike slags occurring in the making of iron and steel should be made into tiles for floors or walls or fashioned into vessels instead of being used as ballast for roads and railroads or thrown away. The chemists and physicists of tomorrow will find use for rubber wastes, sugar beet wastes, tannery wastes. They will be able to reclaim wealth from the waste waters of gas plants, sugar factories and wool washing plants. Increased dividends will come from the material salvaged from the mines and plants for obtaining and purifying metals. Along with each new application of physics and chemistry to industry there will be a new list of waste products to be studied and utilized.

No fair discourse on the subject of applied research could be made without mention of its most important field of service, that of medicine.

So long as medicine had to make its progress by observation alone development was slow, but when experiment was introduced, knowledge went forward by leaps and bounds.

The goal of science in medicine is to determine the nature of the physiological disturbance and what particular cause produced the effect. The second step is to find a remedy or cure for the organs of the body subject to disease and the third step is to discover means of immunity from such disturbances.

It was found by Banting and Best working at the University of Toronto in 1922 that when the pancreas of the human body ceases to function there is a want of insulin in the blood stream without which the sugars made by the digestion of foods cannot be assimilated. The method of supplying the deficiency artificially and thus prolonging life is well known.

Also well known is the study and success of Paul Ehrlich in discovering arsphenamine, or the remedy known as "606" because it was so labeled in Ehrlich's note book. It was the great German dye works which equipped Ehrlich and his corps of medical chemists. The cost was tremendous because no expense of labor or materials was spared. The Institute for Chemotherapy, founded at Frankfort by Ehrlich in 1906, con-

tinues under the patronage of the dye works and has become one of the greatest medical laboratories of the world. It is the hope of scientists and forward looking physicians and all those who look for a better day of health for the human race that the great chemical industry of America may see its opportunity to establish a similar institute and thereby help to determine what products of physical and chemical laboratories may help toward a better level of living. American science has just received a high mark of distinction in the receipt of the Nobel prize in medicine by the three research physicians at Harvard University and the University of Rochester for their work in the treatment of pernicious anemia. American chemistry and physics have also been honored by the award of the Nobel prize to Professor Urey at Columbia for his work on atomic nuclei.

The field of research in health is most inviting. Since 1900 six out of every thousand lives have been saved. This represents the saving of 183 lives every twenty-four hours. In two decades the average length of life has been increased ten years. The annual cost of illness in America is nearly sixteen billion dollars. Since 1900 medical research has been able to save for our country alone 600,000 lives annually, and if our present knowledge could be made effective it is not too much to say that 300,000 more could be saved.

It is probable that at the present time our most expensive waste is in human energy and comfort. It would be difficult to estimate the benefit even in profit of money if biochemical research could find a preventive for tuberculosis, cancer, diabetes, high blood pressure, anemia and other devastating ailments. Probably the greatest loss occasioned by an economic depression is not money but energy, courage and morale of the people. This economic disease also needs the application of scientific research. That the cause and cure can be found and that this social calamity will yield to treatment goes without saying.

Pasteur said "What really leads us forward is a few scientific discoveries and their applications." Progress of civilization as all historians know depends upon the increase and diffusion of knowledge. At a time when people are flushed with a pride of success in producing the material needs for every want, when the physical and spiritual requirements of the average man have been provided beyond his power to measure or to fully appreciate, thought needs to be taken lest we forget the few scientific discoveries as Pasteur said, lest we neglect the neces-

sity for the increase and for the diffusion of knowledge.

It is not the application of science to development of the industries, reduction of the cost of living, production of foods, improvement of health, but it is the production of that knowledge which is applied for the success of these aims which constitutes the first line of offense and defense of the country. Applied research makes use of scientific laws and principles for specific ends but whence these laws and principles? This is the field of that higher realm of adventure in science—namely research in pure science.

The Scottish physicist Tyndall said of us in 1873, "It would be a great thing for this land of incalculable destinies to supplement its achievment in industrial arts by those higher investigations from which our mastery over Nature and our industrial art itself have been derived."

More than $200,000,000 a year is spent on industrial research while the whole income for pure science research does not total $10,000,000. It is not equal to one-tenth of the money spent for cosmetics alone. This margin of money between industrial research and pure science research is greater in America than in any other first class nation.

We point with pride to our great industrial laboratories, industrial institutes and government bureaus, but our pure science research is still confined to the worker in his lone garret, the zealous investigator in government bureaus or private foundations, but mostly in poorly equipped, over worked teachers in college faculties. So much neglected is this vital matter of pure science research that some of the directors of industrial laboratories and government bureaus have sensed the danger and have permitted some investigators to plan their own research even in the field of pure science.

It is to be regretted that there is some damaging confusion in the meaning of the term research. Loose usage has attached the name to all sorts of mere listing, classifying and counting. But it should be remembered that pure science research means an undertaking for the purpose of discovery. When considered from this point of view it is well known that the most fruitful source of pure science investigation has always been the college laboratory. It is clear therefore that the laboratories of our educational institutions and the men conducting research in them become a most important asset in the country's welfare.

The first plea then, in a consideration of our national progress

and that of civilization in general, is a better recognition of the importance of pure science research, and more adequate equipment for college and other laboratories and salaries proportional to the value of the work accomplished. As might be expected we in America have been too little concerned with a problem of such vital importance. It would seem that if it is worth while to have a music week, a health week, a labor day and various other days set aside for fixing attention on worth while interests, we might well appoint a time for reflecting on pure science research and applied science which are the essentials of good living and advancement. We might select the birthday of our Joseph Henry for such a day of reflection since Henry was perhaps our greatest theoretical physicist. Up to the present time an effort to build a suitable monument at Albany where he discovered the principle of electromagnetic induction has not met with success.

This important discovery of electromagnetic induction is generally attributed to Michael Faraday since it was discovered in England and America at the same time. It is scarcely known to the average man in America that Henry contributed this important discovery although, in its application to electromagnets, it accounts for all the force and power of electricity which has added to every man's convenience and comfort.

In 1931 on the centennial of the discovery of electromagnetism by Faraday the English people prepared a week of celebration in London. During that time the original crude apparatus of Faraday was exhibited along with hundreds of devices using the principle. During that week England's great physicists, chemists and engineers, in scholarly addresses, impressed upon the visiting public the importance of pure science research. The story is told that at the time when Gladstone was one of the youngest members of Parliament and had the privilege of observing Faraday's electromagnetic experiments, he asked the discoverer, what it was good for,—to what use it might be put. To which the scientist replied "Well Sir, you might some day even be able to tax it." Gladstone did see the day when it became one of the Empire's greatest sources of revenue.

If the public mind could be brought to see that a fraction of the measureless cost of war could be invested in science and education the world could be made a safe place in which to live, not only to live but to live much better. Our worn out moral philosophy would soon be replaced by a better one, our economic

policy would give way to one which would guarantee justice to every man, we would develop leisure and the wise use of time and we could greatly relieve human suffering and grief and could increase comfort and happiness in every way. Wherever we turn for betterment there pure and applied science stand ready to help. For every dollar expended in agricultural research it has been estimated the financial return is five hundred dollars. Why not make a similar investment in moral, social and economic research and then adopt the results for a similar advancement in these respects?

In a serious consideration of our duty and responsibility as teachers of the coming generation of citizens, we may well ask ourselves, what conceptions shall we give of the importance of producing new knowledge. There is but one answer, that is, the same importance as we give to the advancement of civilization itself. We must impress our students with the fact that if the human race is to move onward and upward then science and first of all pure science is the way.

Andrew Carnegie taught us the value and pleasure of reading by placing a library within every man's reach. What untold advancement might be made by a similar investment in scientific research. Lone investigators still working in the attic should be paid commensurate with the importance of work undertaken, or in proportion to work already contributed. It would not be impossible to rightly judge such undertakings. We have it from reports that such a plan is already working in Russia. Those pure science investigations in institutes and bureaus should be better equipped and the workers paid so that time and energy need not be divided between work and concern for future needs and comforts. Especially the investigators in the colleges and universities should be provided equipment necessary to the success of their undertakings. Every college and university research in pure science should be subsidized by the state or nation for these contributions are the property and benefit of the people of the nation and the world. The suggestion that, for purposes of more adequate support, pure science research be shifted to the industrial laboratories is most unworthy. The natural home of science and the search for new knowledge is in the university from which it must not pass. It is the highest function of the universities to make advances in new knowledge, to test new discoveries and to place their stamp of truth on those they find to be pure. In no other way shall the people have a

place to which they may ultimately turn for knowledge and confidently believe what they are taught. It is certain, therefore, that absolutely nothing must influence the findings and teachings of the universities except to promote their work.

It is to be regretted that the pioneers of new knowledge have not always been received with justice and honor. It is no credit to England that Priestly had to spend his last days in America with his children, or to Germany that Einstein was forced to leave his country, or to France that Lavoisier died on the guillotine. Michael Faraday in his last years was provided a house by Queen Victoria. Roentgen is said to have died in want. In America our scholars are a "brain trust." Yet the world industries tower on the work of such men as, Oersted, Henry, Joule, Ampere, Ohm, Cavendish, Berthelot, Bunsen, Avagadro, Berzelius, VantHoff, Davy, Pasteur, Liebig, Van der Waals, Scheele and many others, not one of whom pursued a practical problem. The basis of electric force and power lies in the discoveries of Oersted, Henry and Ampere; electrochemistry goes back to Sir Humphrey Davy; radio is based upon the electromagnetic waves of Maxwell; X-ray diagnosis began with the work of Crookes and Roentgen; the introduction of radium in medicine began with Becquerel; synthetic chemistry owes its success to the atomic researches of J. J. Thomson, Millikan and Bohr and man's progress, due to his self dependence, recognition of his reliance upon his own energy and power, emanates from Darwin. Just now we have before us the findings of those atomic physicists and chemists who have shown that the exceedingly small but massive nucleus of atoms contains protons, deutons, positrons, and neutrons packed together in some unknown way with stores of energy. We shall pass this knowledge on to the industrial laboratories and await what changes and advancement this too may bring.

Much of the correction of a dangerously mistaken and irresponsible attitude toward pure science, on the part of the public, may be improved by present day teachers. Every instructor has been sufficiently impressed that his every word in some degree modifies the thought and action of the future. Let the teachers of today therefore impress upon the citizens of tomorrow that every industrial advance goes back to the laws and principles of pure science discovered by investigators working for the pure love of extending the bounds of human knowledge. Put it as the foreword of every science textbook that

every step in material, moral and spiritual progress depends upon the discoveries of pure science, upon the unselfish life work of men and women devoted to the purpose of finding more truth.

Let the students be convinced that their conveniences, comforts and health go back to the laboratories of applied science which are founded in turn upon the work of pure science in the universities and institutes. Especially teach the youth of the land that their moral and spiritual codes as much as their food and health depend upon science for their direction, that the advancement of civilization can come only through the revelations of scientific research. Establish in the next generation the unqualified acceptance of the responsibility for the generous support of scientific leadership of the country and the liberal giving of material needs for carrying on its work. If we rise to the advancement of our country we shall have no cause to defend it. Continue the waters of life by safeguarding the spring at the source.

MOBLIKE HABITS OF ELECTRICITY IN RADIO SET FIXES LIMITS OF AMPLIFICATION

The almost moblike characteristics of the particles of electricity flowing through a radio set is what sets the ultimate limit to which engineers can push amplification of faint radio signals in their search for more and more distant reception, Dr. J. B. Johnson and Dr. B. F. Llewellyn of the Bell Telephone Laboratories told the meeting of the American Institute of Electrical Engineers.

The rushing about of the electrons in a radio circuit, wherein they better one another and the wire through which they pass, makes a tiny noise which radio amplification makes louder and louder until finally it may screen out some faint signal.

This noise in a radio set, limiting amplification, is caused by the thermal agitation of the electrons. There is nothing engineers can do about it unless one tried to operate the radio set in a bath of liquid air which, because of its low temperature of hundreds of degrees below zero, would reduce the thermal rushing characteristics of the electrons. This procedure is not practical.

Describing noise in radio circuits and tubes, Drs. Johnson and Llewellyn said thermal agitation noise was the faintest of all obscuring sounds with which radio engineers have to deal.

Each radio amplifier has other noises which, taken together, constitute its natural noise level. Said the scientists:

"The natural noise level is exceedingly low, yet modern amplifiers have reached a stage of perfection where their noise levels are practically at the natural limit. This is true not only for amplifiers built for experimental purposes, but of many amplifiers used in commercial circuits."

Man's search for more and more power and amplification and the detection of fainter radio signals has almost, apparently, reached the limitations fixed by the nature of electricity.

THE USE OF THE TEXTBOOK IN THE EFFECTIVE LEARNING OF GENERAL SCIENCE

By Ellsworth S. Obourn

John Burroughs School, Clayton, Missouri

There can be little doubt but that General Science has bebecome one of the constants in the curriculum of the modern high school. From the experiments of Hanna and Rynearson early in the present century, it has developed into the most important high school science, from the point of view of enrollment, and it is steadily growing.

The reasons for this phenomenal growth of enrollment, especially during the past twenty years, are not hard to understand, for general science came into popularity at a time when interest and enrollment in the older specialized sciences offered in the first year of high school were on the wane. It was also the period of the growth of the Junior High School and educators found in general science a subject which fitted into the conception of this new school unit better than any of the older sciences such as physical geography.

A more important factor however in the growth of general science has been the fact that it has met genuine needs of boys and girls at the age of adolescence. It provides for the shifting interests of this period while at the same time permitting the exploration of the various fields of specialized science, so essential at this period for the development and guidance of youth.

If any program in general science is to be sound it must not lose sight of the fundamental physiological changes which are in progress in the adolescent boys and girls who study the subject. If education is to be concerned with their growth, its aims, content, and methods of instruction must be determined largely in terms of their interests, needs, and abilities.

What are the interests and needs of the adolescent? At the present time we know very little about them. In fact there is now in progress a comprehensive study by an educational commission, backed by many thousands of dollars, attempting to find an answer to this question. However the inability to answer completely at this time with regard to the question of interests is not so distressing as it might seem at first. A little study and reflection will, I am sure, reveal that modern adolescents are

little different in type from adolescents of any period and therefore we can at least be guided to some extent by past experience in the matter.

Boys and girls of early adolescence seem to me to be interested most in those aspects of learning which in general are romantic and adventurous. During this period of their development Moby Dick, King Arthur, and the immortal tales of Jules Verne really live for them. Hero worship is at its height. Tales of pirates and pirating, of exploration, adventure and heroism are read and reread time after time. There seems to be an innate outreach of mind at this time motivated by the desire to explore new fields of experience and to try their wings.

A little farther along the way in this turbulent period (for changes come suddenly and swiftly) we discover that the interests in the romantic and adventurous have shifted to those centered in things immediately around them. The collecting age comes on and with it the desire to understand the forces and factors at work in the environment. They want to know the "what" and "why" of the things that happen about them. The air, fire, food, water, heat and light, the machines on the farm and in the city, the soil which they must till, and how the living things with which they come in contact behave.

Toward the close of adolescence the youth may be seen merging into the adult. He begins to lose the self-centered interests and see himself in relationship to others. Interest develops in problems which have group characteristics and he begins to show keen intellectual outreach. This is the time when in science the boys and girls are interested in and challenged by problems dealing with community health, electricity as a public utility, transportation, communication and the outreaches of astronomy.

This brief summary of the general trends of interests through adolescence is of course only a central tendency and there are individual deviations and variations from it at all levels. Let us turn now to a brief consideration of the needs of the adolescent.

The first need is that these interests should be recognized and provided for in every phase of the curriculum. For unless the learning experiences in school are motivated by interests deep-rooted in the daily lives of the boys and girls, there can be no real growth and no genuine learning.

Boys and girls living in a modern world teeming with the products of a scientific age need to have a background of basic

understandings of science to adequately cope with ordinary life situations. At every turn in the road, and during every hour of their waking lives, they are called upon to make adjustments and interpretations which demand the use and application of the basic concepts of science. In the home, at school, on the farm, and in the city the nervous systems of these boys and girls are continuously bombarded with myriads of sensory stimuli which have science implications, and to which they must adjust in a satisfying manner. To adjust easily to such stimuli, the student must be able to understand and interpret the science of the things about him. This, it seems to me, is one of the most important needs of modern youth.

There is another less tangible but none the less important need of the youth of today which, if it could be adequately met, might well be the panacea for some of our present day economic and political ills. This need is that the boys and girls who go through our schools might in some way become better fortified against prejudice, superstitions, unfounded beliefs, emotional thinking, and other aspects of thinking loosely which might be safeguarded by proper training in the basic habits which lie back of an intelligent and functional scientific attitude toward the problems of modern life.

There is little doubt but that the scientific attitude rests upon specific habits which are capable of development or modification. Some of these are the habit of openmindedness, the habit of accuracy in observing and reporting data, the habit of intellectual honesty, the habit of suspended judgment, the habit of reacting only in the light of proven evidence, the habit of analytical and critical thinking, etc. If by any means or devices we are able to inculcate or modify these habits in a positive way, we will have rendered a service to modern youth which will be theirs long after the laws, facts and principles have been forgotten.

If the points made in the preceding paragraphs on interests and needs of the adolescent are valid, it would seem that specific principles regarding the selection, organization, and presentation of the content of General Science might be easily deduced. Thus the content should be selected in accordance with the changing interests and needs of the adolescent learner. It should be organized so that learning is natural, efficient, and effective. It should be presented in such a manner as to both insure the mastery of the knowledge elements and the habits of thinking

fundamental to the development of a scientific attitude.

To me effective learning in any subject implies not only a mastery of the laws, facts and principles which make up its body of content and the development of those habits of mind fundamental to a scientific attitude, but also the insurance that these modifications in the personality of the individual will function in enabling him to more easily and satisfyingly adjust to the world about him.

What is the function of the textbook in securing this effective learning? In so far as I am able to see the textbook becomes an important tool in attaining mastery of the knowledge essentials while at the same time fostering a method which may lead to improved ability in scientific thinking.

One can read in the preface of many science textbooks that the book tends to inculcate a scientific attitude and the ability to think scientifically in the learner. An examination of many of these books will reveal that they are organized along the lines of the older specialized sciences. If a scientific attitude of mind rests upon specific and desirable habits then they should be developed in ways which experience and experiment have revealed to be effective. I should like to challenge statements that books organized chiefly from the logical point of view can go very far in developing scientific thinking on the part of the learner. While it has been demonstrated that extensive reading is one factor which is effective in developing the scientific attitude, there are others which seem to me to be equally as important. Therefore a science textbook which is only a reading book can hardly be expected to go very far in producing effective learning as I have defined it.

Assuming that the wise use of most any of the more commonly used general science texts can yield mastery of the basic content of the course, they will have gone only half way toward effective learning. The next step is that the text should foster a method of approach to the mastery of content and the necessary learning experiences which will give recurrent practice in those habits of thinking basic to the development of a scientific attitude.

Essentially the scientific method is a problem solving method. The scientist, as he meets a problem situation, delimits it, studies available literature related to it, attempts to suggest experimental proceedures which will add new information about the problem, sets up tentative hypotheses to account for ob-

served conditions, tabulates his data, draws logical conclusions and then attempts to test his findings by applying them to new situations. If the textbook in general science is to go farther than mere reading can go in inculcating a scientific attitude of mind in the learner, it must make use of as wide a variety of learning experiences as possible. These must have been selected on the basis of their ability to contribute directly to the development of this attitude of mind. It must be a book which uses a problem solving method and the problems selected for inclusion must be of the type met by boys and girls in real life situations and not adult problems and generalizations. For if learning is to be real, the learner must accept the problems as worthwhile to him and engage in their solution wholeheartedly.

Given a textbook with a problem solving method and defensible problems the method of the book must then utilize specific learning experiences aimed, not alone at the mastery of content, but at the solution of the selected problems. For an ability to use the scientific method must come from active and repeated practice in solving real life problems in as favorable an atmosphere as it is possible to create in the classroom.

The experimental work must come at a time in the solution of a problem when it is most needed. It must further serve a real function in giving the student new and first hand knowledge about the problem and not be mere laboratory busy work. The experimental proceedures should also be so arranged as to allow the student to do some thinking for himself. The edge and value are removed from much of the experimental work in high school science today because the student is told what to do, what to see and finally what he has seen. Little room is left for the initiative of the learner to function in suggesting possible proceedures and trying them out, nor is he provided, as a usual thing, any opportunity to evaluate the results and draw logical conclusions from them.

Thus far we have been thinking of the function of the textbook in producing effective learning chiefly from the standpoint of the assimilative period in the learning cycle. It may function equally as well in developing other habits fundamental to the scientific attitude at other periods in the learning cycle.

In the initiatory period the problems for a given topic are set. Here the student may be led by means of the textbook into discussions which will give practice in critical analysis and in delimiting problems. In the culminating period of the learning

cycle the student may be guided by the textbook into reading incidents from the lives and researches of great scientists, reporting results of original experiments which have called upon their resourcefulness, and in formulating generalizations from mastered facts and principles.

Ordinarily we stop at this point in the learning cycle. We bring the student up to a realization of the broad understandings of a unit of work and leave him stranded and bewildered in the face of new science experiences to which he must adjust. It would seem to me that just as the learning cycle starts with practical problems from the life experience of the learner, it must culminate in experiences which demand the application of the learning acquisitions. We must see to it that the student understands the step of application and guide him wisely as he takes it. If we make our textbooks work to one hundred percent of their potentialities, effective learning for the student must result.

It has been said many times by great and wise men that we are living in an age of science. There seemingly can be little doubt of this for the experiences of a day or an hour are teeming with situations which have their problems deeply rooted in science. Modern medicine, modern transportation and communication, modern agriculture, the modern home, all bespeak the implications and ramifications of science in the life of the present day. The celebration of a century of progress has just closed in Chicago and a few hours spent at that great spectacle revealed on every hand this same import of science in modern living.

Modern biology and medicine have lengthened the expectant life span of mankind. Modern chemistry has produced new medicines, dyes, textile fibers, and plastics. Modern physics and engineering have eased the life of man and woman and brought to the resultant leisure the radio, telephone, and automobile. Modern geology and archeology are continuously opening up the past of living things while the astronomers are building new instruments of research through which they will open the more distant recesses of space. Truly it is not difficult for one to become over awed at the accomplishments of modern science and its potentialities for a glorious future!

And yet when we reflect on the present and attempt to see causal conditions in the chaos about us we begin to wonder if after all we are living in an age of science. Life is buffeted on

every side from the cross tides of economic disturbances. Many are starving in the face of plenty. Fear and superstition are rampant on every hand. The genius of science is turned to playing the competitive game of war which may eventually spell doom for our civilization. On the one hand we see science the giver of life and plenty and on the other, science the destroyer of life and ideals.

As persons trained in science may we not reasonably expect to find through analysis the causes of such antithetical conditions in modern life? An analysis of many of the perplexities which face us today will, it seems to me, reveal certain basic ills for which science is not altogether to blame and yet for which science and education may hold the key to a brighter future. Why do people fear and are they superstitious in enlightened times like these? Why do astrologers, palmists, mediums, diviners and other quacks still ply their trades? Why are we beset by so many economic ills? May not the answer be in part at least, the failure on the part of people in general to understand and use effectively those fundamental attitudes and habits of mind which have so long characterized the work of the scientist and have made possible his great contributions to modern life? And further cause for these conditions, it seems to me, may lie in the lack of understanding or the failure to apply, on the part of laymen, those broad generalizations or concepts of science which have influenced the behavior of people in securing complete and satisfying adjustment to the life and forces around them.

In the face of present conditions in the world about us and in the preeminent position occupied by science in modern life, there is a challenge to us as science teachers to produce results which will not be measured and evaluated primarily in terms of time spent in the classroom, or in the massing of unrelated facts but rather in terms of the way in which our students are able to make use of their learning acquisitions in adjusting to the modern social order. Only through effective learning may we hope to bring about any significant change in their behavior.

"The second annual interscholastic mathematics contest for high schools in the metropolitan area of New York City will be held by Epsilon Chapter of Pi Mu Epsilon at Washington Square College, New York University, on Saturday, May 4, 1935."

HISTORY OF MATHEMATICS IN AMERICA

By G. A. Miller
University of Illinois, Urbana, Illinois

Recently the Mathematical Association of America published a small volume (vii+209 pages) under the title *A History of Mathematics in America before 1900* by David Eugene Smith and Jekuthiel Ginsburg, being number 5 of the "Carus Monograph Series." In the introduction of this volume it is stated that "in a general way the plan has been to consider the term 'America' as including the territory north of the Caribbean Sea and the Rio Grande River." As very little is said in this volume about the development of mathematics outside the present limits of the United States it covers practically the same territory as a much larger volume (400 pages) published in 1890 by the Bureau of Education under the title *The Teaching and History of Mathematics in the United States* by Florian Cajori. The fact that the latter of these two volumes includes the term teaching in its title does not imply a difference in content since the history of its teaching is a part of the history of our subject.

Neither of these two volumes devotes any space to the mathematics of the American aborigines. While this mathematics is very interesting it should be emphasized that it involves not a single contribution to the advancement of our subject. The white settlers who came in contact with the aborigines did not receive from them any mathematical knowledge which was equal to that which they had brought with them from their native lands. The latter was frequently very meager and the strenuous pioneering life frequently resulted in still lower mathematical attainments on the part of the immediately succeeding generations. The mathematical development of the early European settlers in America can however not be clearly understood unless we bear in mind that many of them came from the most advanced mathematical countries at that time and brought with them a keen appetite for knowledge as is evidenced by the early establishment of colleges. For instance, Harvard college was established in 1636—only sixteen years after the landing of the "Pilgrims."

In order to understand the relatively insignificant contributions towards the advancement of mathematics made in America before the latter half of the nineteenth century it is desirable to note here some of the remarkable advances in our

subject made in Europe from the time when early white settlements were made in America up to the middle of the last century. These advances include the founding and early development of the analytic geometry and of the calculus, a satisfactory theory of negative numbers and of the ordinary complex numbers, the founding and the early development of function theory and of group theory, the construction and the use of logarithmic tables, the early development of determinants, a satisfactory theory of infinite series and of their usefulness, a simplification of trigonometry resulting from the use of the ratio definitions of the various trigonometric functions, and giving rise to such formulas as $\sin^2 x + \cos^2 x = 1$ instead of $\sin^2 x + \cos^2 x =$ the square of the radius, etc.

It should not be assumed that no efforts were made by American mathematical writers while these remarkable advances were being made in Europe. In particular, just about the time when a satisfactory theory of the negative numbers was developed in Europe, at about the beginning of the nineteenth century, J. Mansfield published at New Haven an undated volume entitled *Essays, Mathematical and Physical* in which he tried to develop a satisfactory theory of negative numbers and of the trigonometric functions. In his volume entitled the *Early Mathematical Sciences in North and South America* (1928) Florian Cajori calls this "the first volume of mathematical research issued in America" (page 20), but the theory of negative numbers given by J. Mansfield was not adopted by later writers and he did not use the ratio definitions of the trigonometric functions. The book however won for him the friendship of Thomas Jefferson who appointed him in 1803 Surveyor-General of the Northwestern Territory.

To exhibit more forcibly the great disparity between the mathematical developments made in Europe and those made in America from the time of the early white settlements in the territory now known as the United States of America up to the middle of the nineteenth century it may be noted that Great Britain had then J. Napier (1550–1617), I. Newton (1642–1727), and W. R. Hamilton (1805–1865); France had R. Descartes (1596–1650), P. de Fermat (1601–1665), P. S. Laplace (1749–1827), A. L. Cauchy (1789–1857), and E. Galois (1811–1832); Germany had G. W. Leibniz (1646–1716), C. F. Gauss (1777–1855), and J. Steiner (1796–1863); Italy had J. F. Riccati (1676–1754), J. L. Lagrange (1736–1813), and P. Ruffini (1765–

1822); Switzerland had L. Euler (1707–1783), and the Bernoullis; Norway had N. H. Abel (1802–1829). One cannot find a single name of a mathematician living in America during this period who was as influential as the least one among these.

As it would obviously be impossible to give in the space available here a satisfactory treatment of the broad subject of this article and as the two books mentioned in the first paragraph thereof contain a large amount of interesting information relating to this subject it may be desirable to give here a few views which differ somewhat from those expressed in these books. Teachers of mathematics who are interested in the development of their subject in our own country may find it helpful to discuss with their students the merits of some discordant historical views relating thereto since a deeper insight into the subjects concerned can often be obtained in this way and it is very desirable to cultivate the habit to accept historical statements relating to mathematics only after a careful consideration of their bearings. It should be emphasized that the views expressed by the present writer in what follows are presented as suggestions which should be accepted by the reader only if they meet his approval.

On page 2 of the former of the two books under consideration it is stated that "as to mathematics, the farmer and artisan needed merely the ability to add and subtract numbers, rarely to multiply, and almost never to divide." This seems to represent an unfair view as regards the importance of elementary mathematics to the farmer and artisan even under somewhat primitive conditions, and it is in disaccord with the much more advanced mathematical developments in the early Babylonian and Egyptian civilizations. Many uses for multiplication and division suggest themselves in a comparatively primitive society which readily occur to all who consider the matter, and it seems unfair to the early white settlers to assume that their intellectual interests did not extend to multiplication and division so that it could be truly said of a large part of them that they needed "rarely to multiply and almost never to divide."

On page 10 of the same volume it is stated that "it is not in the schools that the advance in mathematics in the sixteenth, seventeenth, and eighteenth centuries in America is to be found, but rather in the quasi-astronomical work of the astrologers and makers of almanacs, the two classes often merging into one." This quotation is apt to be even more surprising to the

thoughtful reader than the one noted in the preceding paragraph. He will look in vain in this and in other histories for substantial evidences for its support. In fact, on page 65 of the same volume he finds the significant contrary statement that "the first three centuries of our history were, as we have seen, barren of achievement in the domain of mathematics." If there were no achievements in mathematics such an advance could not have appeared in the work of the astrologers and makers of almanacs. The fact that these people used some elementary mathematics is a very different matter.

Since more than a hundred American mathematicians attended the organization meeting of the Mathematical Association of America, which was held at Columbus, Ohio, December 30–31, 1915, and was reported in the *American Mathematical Monthly* as its official organ, January, 1916, many of the readers of the volume under consideration have doubtless noticed discrepancies in the following quotation from page 117: "A year after the founding of the Mathematical Association of America (1916), largely through the efforts of Professor H. E. Slaught, the *Monthly* was made its official organ." This quotation also illustrates the fact that the authors of this volume did not always confine themselves to the upper limit "before 1900," and hence its title is somewhat misleading. A striking instance of this is that in the list of American dissertations, pages 150–153, those of 1900 are included. At Chicago University there were four dissertations before 1900 and seven in 1900. In the lists of articles given towards the close of the volume one by W. F. Osgood (page 170) is the only one which was published as late as 1900. The statement that it was written before 1900 is not very illuminating since many other articles written by Americans before 1900 were also published later.

More than one-half of the latter volume noted in the first paragraph of this article appears under the following two headings: "Influx of English mathematics," pages 44–97, and "Influx of French mathematics," pages 98–277. On page 44 of this volume the former heading is followed by the dates 1776–1820. The thoughtful reader is naturally surprised to find that an influx of English mathematics is said to have begun at the time when the colonies which were later to become the United States declared themselves as independent from England and began to wage a long war to establish this independence. One would naturally suppose that this was the time when these colonies

sought to become also independent from English mathematics, and the large number of arithmetics by American authors which appeared in these colonies during this time, beginning with the one by Nicholas Pike (1788), seems to confirm this supposition.

The spirit of these times is illustrated by the following quotation from a letter written by George Washington in politely acknowledging a copy of Pike's arithmetic: "Its merits being established by the approbation of competent judges, I flatter myself that the idea of its being an American production and the first of the kind which has appeared, will induce every patriotic and liberal character to give it all the countenance and patronage in his power." These facts make it appear at least questionable whether the given period can be properly described as that of the "Influx of English mathematics" notwithstanding the fact that the English language was then, as later, most widely used by the white settlers in the territory which is now known as the United States and hence books in the English language naturally had some advantage over those which appeared in other languages.

To explain the heading "Influx of French mathematics" it should be noted that at the time of the Revolutionary War and for some time thereafter the French were doubtless ahead of all other nations as regards new mathematical developments, and their textbooks were usually superior to those used in other countries. Hence when J. Farrar (1779–1853) of Harvard College and others began to publish textbooks based on foreign works they naturally tried to select the best. It should however be noted that these were not always due to French authors. One of the first textbooks published by J. Farrar is his algebra (1818) based on the algebra of L. Euler. In view of the fact that Euler's complete works alone are expected to require more than sixty volumes the following quotation relating to J. Farrar is obviously in need of modification: "His interests were largely in astronomy, but he did much for elementary mathematics in this country through his translations (1818–1825) of the works of Euler, Lacroix, Legendre, and Bézout, and through his publication of a number of textbooks," page 96 of the former of the two volumes under consideration.

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THE COEFFICIENT OF ABSORPTION OF STUDENTS IN CHEMISTRY

By R. H. Steinberg
Chicago, Illinois

INTRODUCTION

The class consisted of eleven students in relatively regular attendance and about ten others who attended intermittently. They were gathered from various high schools in the city of Chicago and met at the University of Chicago, School of Education. All were high school seniors whose ages ranged from sixteen to eighteen years.

HOW THE CLASS WAS CONDUCTED

The first ten minutes of the session were devoted to giving a twenty-five question true-false test on the material to be covered in the lecture. Then the lecture was given, sometimes as short as thirty-five minutes and sometimes as long as an hour and a quarter. The lectures were informal, questions being asked and answered by both lecturer and students. At the close of the lecture, general discussion was invited, but seldom lasted more than five or six minutes. Then the initial test was repeated. The tests were scored using the relation score equals rights minus wrongs. The students were instructed not to guess. Different codes were used in making the tests and occasionally no code was used. The difference in the grades made on the test before and after the lecture, I termed the Coefficient of Absorption.

The tests were read to the students. Care was taken in making the tests that no question was made up of too many words. Each question was repeated but once. The questions were such that rarely was it necessary to utilize more than two steps in reasoning. It was thought that too complicated reasoning might do more harm than good because of the questions being oral. All lectures were prepared in advance.

For the first month, the class met only on Fridays but thereafter met both on Mondays and Fridays. At various sessions guest lecturers were present. However, only at three of these sessions were tests given. It was thought that an occasional talk by some specialist would inject some of his enthusiasm into the students. Foremost among these lecturers were Doctors

E. R. Downing, T. F. Young, and H. N. DaCosta, all of the University of Chicago. The author, realizing that chemistry becomes a very dry subject when taught without laboratory work, permitted the students to assist him in his own chemical research work, which was also being carried on at the University of Chicago.

THE OUTLINES

The outlines are carbon copies of the students' class notes. They are handed in at the end of each lecture. Outlines were not collected at the first four lectures, this technique not having been decided upon. Outlines were not collected at the last three lectures due to the excellent records made in the previous seven lectures.

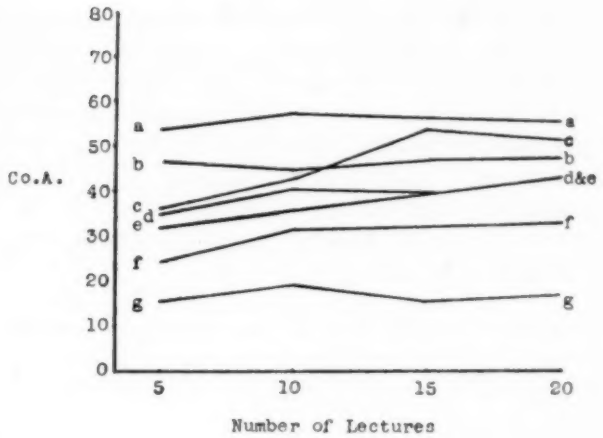
At the beginning of the course, the marks of the outlines were not very good in many cases. However, they continued to improve to a point where for the last seven lectures there were one C and one B, all the rest being A's.

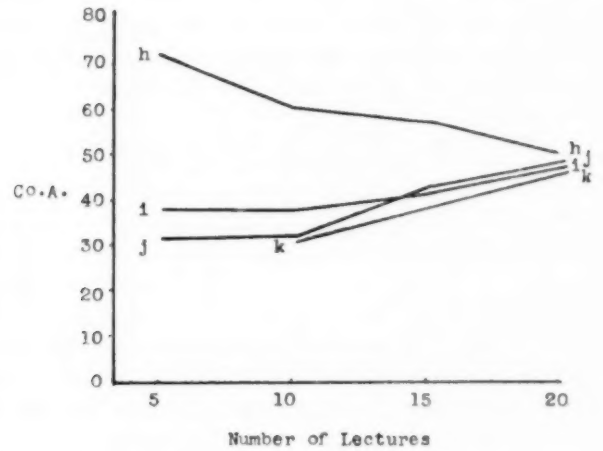
Lecture No.	5	6	7	8	9	10	11	12	13	14	15	16	17
No. of A's.	12	8	8	5	12	5	12	8	9	7	8	8	7
No. of B's.	2	2	5	8	1	0	0	0	0	1	0	0	0
No. of C's.	2	3	1	2	0	4	1	0	0	0	0	0	0
No. of D's.	1	1	0	1	0	0	0	0	0	0	0	0	0
No. of F's.	0	1	0	0	0	0	0	0	0	0	0	0	0
Average	5	4	5	4.1	5.8	4.2	5.7	6	6	5.8	6	6	6

I outlined lectures 5 and 6 on the board myself, also lecture 12. Since the outlines were considered only as incidental to the main purpose, it was not compulsory to hand them in. The average was calculated on the basis of A, B, C, D, and F equalling respectively 6, 4, 2, 0, and -2.

THE COEFFICIENT OF ABSORPTION

Assuming that less than a ten point difference in the maximum and minimum points in the Coefficient of Absorption curve of any individual student is not a critical difference, the Coefficient of Absorption (hereinafter termed the Co.A) of eight of the ten students who had attended nearly all of the lectures was constant. The eleventh student in regular attendance started in at the fifth lecture. The accompanying set of graphs will give some idea of how constant the Co.A. really is. Each curve is for one student. The point on five lectures represents the average for the first five lectures. Similarly, the point on ten lectures represents the average for the first ten lectures, et cetera.





In addition to the eleven students in regular attendance, there were seven others whose attendance was relatively regular. Of these seven, five have Co.A's constant within the ten point margin, and the other two have Co.A's constant within a twelve point margin.

RELATION OF THE Co.A TO THE OUTLINE

Lecture No.	5	6	7	8	9	10	11	12	13
Co.A. Av.	45.3	51.3	46.3	25.1	8.0	55.5	33.1	40.3	57.2
Outline Av.	5.0	4.0	5.0	4.1	5.8	4.2	5.7	6.0	6.0

Lecture No.	14	15	16	17
Co.A. Av.	46.7	54.4	56.0	57.0
Outline Av.	5.8	6.0	6.0	6.0

Co.A. Av. is the Coefficient of Absorption average for the entire class at the designated lecture. Outline Av. is the average for the class on that day. Lectures 8 and 9 were given by guest lecturers. Lecture 9 was exceedingly long and difficult.

The fact must be borne in mind that the quantity of material and the degree of difficulty of the material in the lectures was by no means constant.

The above tabulation shows no correlation between the Co.A. and the Outline Average.

RELATION OF INDIVIDUAL CO.A TO INDIVIDUAL OUTLINE

Student	a	b	c	d	e	f	g	h	i	j	k
Co. A. Av.	54.7	46.7	51.1	43.2	45.0	32.7	17.5	48.8	46.0	46.6	44.5
Outline Av.	4.0	6.0	5.5	5.5	6.0	5.4	4.2	5.3	4.5	6.0	5.8

It is interesting to note that the individual with the highest Co.A. average for the course received the lowest average mark on the outlines. The above tabulation shows no relation of the student's Co.A. to his ability to outline his work.

RELATION OF MARKS ON TEST ON SCIENTIFIC THINKING TO THE CO.A

	Av. Scientific Thinking	Co.A. after 10 lectures	Co.A. after 20 lectures
Boys Av.	64.8	30.6	39.7
Girls Av.	75.3	41.9	49.8
Difference	10.5	11.3	10.1

The first column represents the average grade the two sexes made on the test entitled *Some Elements of Scientific Thinking* by Elliot R. Downing, University of Chicago, School of Education. Columns two and three are self-evident.

The constancy of the differences suggests some relation between the students' abilities to think scientifically and their Coefficients of Absorption.

TEST ON LECTURE VI

1. When a liquid evaporates, its own temperature is lowered.
2. The vapor tension of a liquid is directly proportional to the temperature.
3. The boiling point of a liquid is that temperature where the vapor tension becomes equal to zero.
4. Water and alcohol may be separated by destructive distillation.
5. The heat of vaporization is the amount of heat necessary to change one gram of a liquid to the vapor state at constant temperature.
6. The heat of fusion is the amount of heat necessary to change one gram of a solid to the liquid state at constant temperature.

7. The heat of sublimation is equal to the sum of the heats of fusion and vaporization.
8. When a liquid is super-cooled, its temperature is higher than the melting point.
9. All hydrates have the same vapor pressure.
10. When a substance is efflorescent, it takes water out of the air.
11. Solutions may be defined as homogeneous mixtures.
12. Some gases are very soluble in water.
13. Ordinary diffusion in a liquid is a very slow process.
14. Some saturated solutions may be very dilute.
15. A molar solution is one which contains one gram molecular weight of the solute in one hundred cc. of solution.
16. All molar solutions are normal solutions.
17. A supersaturated solution may be in equilibrium with some of the solid solute.
18. The solubility of gases in liquids increases with an increase in temperature.
19. The solubility of gases in liquids increases with an increase in pressure.
20. The vapor pressure of a solution is always lower than the vapor pressure of the pure solvent.
21. The lowering of the vapor pressure is proportional to the number of dissolved particles.
22. The freezing point of a solution is lower than that of the pure solvent.
23. The boiling point of a solution is lower than that of the pure solvent.
24. An increase in temperature makes all substances more soluble in water.
25. Molecular weights can not be determined from freezing point data.

CONCLUSIONS

1. The Coefficient of Absorption of a student remains approximately constant.

2. The Coefficient of Absorption of a student shows no correlation with the student's ability to outline his work.

3. The student's ability to think scientifically seems to be a direct measure of his Coefficient of Absorption.

At its annual business meeting in Pittsburgh, Pa., December 31, 1934 the Mathematical Association of America elected the following officers:

President for 1935–36: Professor D. R. Curtiss, Northwestern University.

Vice-Presidents for 1935: Professors L. L. Dines, Carnegie Institute of Technology; A. J. Kempner, University of Colorado.

Members of the Board of Trustees for a three-year term: Professors H. E. Buchanan, Tulane University; Arnold Dresden, Swarthmore College; E. R. Hedrick, University of California at Los Angeles; F. D. Murnaghan, Johns Hopkins University.

Professor W. R. Longley, Yale University, was nominated as representative of the Association on the National Research Council for a three-year term from July 1, 1935, in succession to Professor H. L. Rietz.

Professor J. O. Hassler, University of Oklahoma, was appointed a member of the Board of Trustees to fill the vacancy vaused by the election of Professor Curtiss as president, the term to expire in January 1937.

THE THIRTY-FOURTH ANNUAL CONVENTION OF THE CENTRAL ASSOCIATION OF SCIENCE AND MATHEMATICS TEACHERS

The Thirty-Fourth Annual Convention of The Central Association of Science and Mathematics Teachers was held last November 30th and December 1st at Indianapolis, Indiana. The sessions were all held in the Hotel Lincoln which furnished adequate accommodations and pleasant environment for the Association. The president, Miss Katharine Ulrich, of the Oak Park-River Forest Township High School, the Local Arrangements Committee, headed by Principal W. G. Gingery of the George Washington High School, Indianapolis, and the chairmen of the various sections had prepared a program of great interest to the membership. The large attendance at all the sessions gave evidence of this interest.

A meeting of the Board of Directors was held in the Italian Room of the Hotel Lincoln on Thanksgiving evening preceding the opening of the convention and many items of business were adjusted. This cleared the way for a successful meeting. Reports by the Business Manager, the Editor, and the Chairman of Standing Committees were made and laid on the table for future action. The resignation of Miss Villa B. Smith as a member of the Board was accepted with regret and Mr. F. R. Bemisderfer was elected to finish out the unexpired term.

THE FRIDAY MORNING GENERAL SESSION

The Friday morning session opened with music by an instrumental trio from the Music Department of Arsenal Technical High School of Indianapolis after which the president Miss Ulrich, introduced Assistant Superintendent Daniel T. Weir of Indianapolis Schools, who gave the address of welcome, that he, as an old member of the Association, could do in a most effective way. The response for the Association was made by Mr. O. D. Frank of the University of Chicago in his inimitable manner.

The vice-president, Joel W. Hadley of Shortridge High School, Indianapolis, then introduced Mr. Cecil Calvert, Superintendent of the Indianapolis Sanitation Plant, who gave a most interesting and instructive lecture on *Waste Disposal* giving an historical account of the methods from ancient times up to the most modern.

Dr. H. C. Bryant, Assistant Director of National Park Service in the United States then gave a lecture on the *Conservation Policy of the National Park Service.* He pointed out that the Government wishes not only to preserve natural conditions in places for popular enjoyment and instruction but also to preserve in certain places all forms of life, even those detrimental to human life, under exact natural conditions where the specialist may study apart from the popular crowd. Thus, he would establish sanctuaries for rattlesnakes where only the occasional specialists might go to study them. They keynote of his speech was *Save the primeval*—Always have some places absolutely untouched by man.

A departure was made this year in placing on the program two distinctly educational lectures. The first of these was by Dr. J. E. Stout of Northwestern University School of Education who spoke on *New Concepts of Secondary Education and Resulting Curriculum Reorganization.* The second was by Dr. Harold T. Davis of Indiana University, who spoke on the subject, *Can Man's Group Activity Be Measured?*

Following the luncheon in the main dining room where informal dis-

cussion was the program of the hour, the Section meetings were held in different rooms of the hotel, separate reports of which follow.

BIOLOGY SECTION

The Biology Section of the Central Association of Science and Mathematics Teachers met in Indianapolis, November 30, 1934 at 1:30 P.M. in the Lincoln Hotel. After calling the meeting to order, the chairman, O. D. Frank of the University of Chicago, appointed the nominating committee, R. B. Simon, Chr., Ray Ankenbrock, and P. W. Holaday. The program followed. Dr. W. L. Beauchamp of the University of Chicago, discussed "The Psychological Basis of the Unit Method." Following this, Wesley Minear of the Quincy High School of Quincy, Illinois discussed, "Bringing 'Em Back to Life."

The chairman of the nominating committee reported the nomination of Mrs. O. Olive Dunham, Collingswood High School, Cleveland, as chairman of the biology section for 1935, Harvey Milford, Denby High School, Detroit, Michigan, as vice chairman, and J. W. Kendrick, Arsenal Tech. High School, Indianapolis, Indiana, as secretary. Mr. Simon moved the adoption of the report. It was seconded and adopted by the section.

An interesting discussion of the reports of the afternoon followed, pleasantly accompanied by the enjoyment of Indiana apples obtained through the efforts of Joel Hadley and the chairman, O. D. Frank. Adjournment followed.

MARY A. BENNETT, *Secretary*

CHEMISTRY SECTION

Mr. Davis called the Meeting to order. Mr. Davis appointed the Nominating committee as follows: Mr. A. F. McLeod, Chairman, Sullivan High School Chicago; Mr. C. O. Pauley, Valparaiso, Indiana; Mr. F. R. Bemisderfer, East Technical High School, Cleveland.

Following the appointment of Nominating Committee the following papers were presented to the Section.

1. "The Technology of Coal Tar," read by Dr. I. H. Derby, Director of Research Laboratories, Reilly Chemical Corporation, Indianapolis. Dr. Derby discussed the history of coal tar and its products, presented their applications and displayed numerous samples.

2. "A Modern View of Chemistry," read by Dr. E. A. Wildman, Earlham College, Richmond, Indiana. Dr. Wildman's paper dealt with the presentation of ionization; acids, bases, and salts; and other chemical theories from the standpoint of the more recent discoveries coming out of the Electron theory. (Dr. Wildman's paper was published in the February issue of this Journal.)

3. "What Shall We Teach in Chemistry," read by G. M. Bradbury, Lakewood High School, Cleveland Ohio. Due to the lateness of the hour Mr. Bradbury, made his talk very brief, presenting the salient points to be covered in organizing a course in Chemistry.

There was no discussion of the papers from the floor owing to the lateness of the hour and the desire of many of the members attending meeting to take the trips to Industrial plants following our Meeting.

The Nominating Committee reported as follows:

Chairman: M. J. W. Phillips, High School, West Allis, Wisconsin.

Vice-Chairman: A. R. Stacy, Washington High School, Indianapolis, Ind.

Secretary: J. L. Van Horn, Lincoln High School, Cleveland, Ohio.

The report was adopted as read by A. F. McLeod, Chairman for the Nominating Committee.

The Survey Committee then reported that the replies to the questionnaire published in the Journal had been delayed and were few in number, but that the majority of those sent in recommended a double period for Chemistry. The full report of the findings of this committee will be published in the Journal in the near future. At the close of the report a motion was made that the committee be continued for another year. Motion seconded and carried.

M. J. W. Phillips presented the following resolution:

Whereas,

There is a movement among the Professors of Education in some of our Universities and among the officers in the Education Departments of some of our States to abolish Physics and Chemistry as individual subjects and substitute for them a rewritten combination of the two subject matters to be known as Physical Science I, and Physical Science II, and Whereas,

The content of these two subjects is of a widely different nature and when presented in the approved manner requires distinctly differently-equipped laboratories,

Therefore BE IT RESOLVED,

That the Chemistry Section of the Central Association of Science and Mathematics Teachers express its firm disapproval and determined opposition to the movement.

In the discussion of the resolution it was brought out that Physical Science I & II was being used in New York State as a prerequisite to Physics and Chemistry but that this resolution concerned those states, (Wisconsin in particular) which were considering abolishing Physics and Chemistry as such.

Motion:

To voice disapproval of Physical Science I & II as a substitute for Physics and Chemistry and suggesting that the Section take the aggressive rather than the defensive in this matter. Motion carried.

Motion:

That the matter of a study as to the desirability or non-desirability of the New York System of Physical Science I & II be referred to the Survey Committee, motion carried.

Meeting adjourned to the General Session.

ALLAN R. STACY, *Secretary*

ELEMENTARY SCIENCE SECTION

The third meeting of the Elementary Science Section was held November 30, 1934 at 1:30 P.M. in the Travertine Room, Hotel Lincoln, Indianapolis, Indiana.

The Chairman Miss Bertha M. Parker was absent due to serious illness of her father. Miss Florence G. Billig Vice-chairman, called the meeting to order.

The following program was given:

A Demonstration Lesson With Fourth Grade Children, "How Some Furbearing Animals Protect Themselves." Lilliam Hethershaw, Drake University, Des Moines, Iowa. (Twenty-two 4B pupils from school No. 27, Indianapolis, Indiana, Miss Florence Nicolai, Teacher.)

Limestone: A Sixth Grade Science Unit. Helen Dolman, Michigan State Normal College, Ypsilanti, Michigan.

Factors Conditioning the Development of Science Understandings. Gerald-

ine Shontz, Training School, Indiana State Teachers College, Terre Haute, Indiana.

The fourth part of the program "Materials and Equipment for the Elementary School Program," was not given due to the absence of Mr. Ellis Persing, Western Reserve University, Cleveland, Ohio.

The minutes of the last meeting were read by the secretary and approved.

The nominating committee consisting of Miss Elizabeth Downhour, Butler College, Indianapolis, Chairman, Miss Louise Herrick, Rockford, Illinois and Miss Emily Wright, School #41 Indianapolis, presented for officers for the next year as follows:

Chairman, Florence G. Billig, College of Education, Wayne University, Detroit, Michigan.

Vice-chairman, Lillian Hethershaw, Drake University, Des Moines, Iowa.

Secretary, Geraldine Shontz, Training School, Indiana State Teachers College, Terre Haute, Indiana.

It was moved, seconded and unanimously voted that the report of the nominating committee be accepted.

Between forty and fifty persons were in attendance at the meeting.

LILLIAN HETHERSHAW, *Secretary*

GENERAL SCIENCE SECTION

The meeting was called to order by the chairman, Mr. Nathan Neal, at 1:45 P.M., Nov. 30, in room 1309 of the Hotel Lincoln in Indianapolis.

The Chairman asked Miss Florence Hamill of Indianapolis and Miss Alma Thomas of Cleveland to confer on nominations.

Three papers were given at the meeting. Two of the papers dealt with the work in general science in the schools and the third was an account of a scientific expedition.

"General Science in Indianapolis," by Carl F. Hanske. The paper tells of the development of the Indianapolis course of study for science in the seventh, eighth and ninth grades, and the incorporating of it into the curriculum of the junior high school. The course was developed under the direction of the assistant superintendent and curriculum director, with about 600 teachers assisting. The real work of planning the course was done by a committee of five junior and senior high school teachers. This committee after determining their objectives, set to work to survey the science field and select the material to be taught. The material was then organized into units and arranged in tentative placement. The units were then placed in the hands of teachers to try out. During the development of the course eminent educational authorities were consulted. A list of units as set up are included in the paper, also the time allotment for each grade with the suggested use of work book and texts.

"Best Use of the General Science Textbook," by Ellsworth S. Obourn. Following a brief summary of the general trends of interest of the child through adolescence, the paper discusses the needs of adolescence, drawing conclusions as to the selection of material, organization and presentation of general science, to procure effective learning. In this effective learning the text book is an important tool. The text book must be more than a reading book. It must develop a scientific attitude on the part of the learner toward life situation problems, so that the students may make use of their learning acquisitions in adjusting themselves to the modern social order.

"Thirteen Months Within the Arctic Circle," by Leonard R. Schneider.

This paper deals with the preparation of the author for the expedition to Greenland and the life while there studying the climatic conditions, with the idea of establishing a route for airplanes from Canada to Europe, with stops at Laborador, Greenland and Iceland. The lecture was accompanied with about fifty slides taken during the time of the expedition.

The report of the nominating committee was accepted and the following were elected to office for the coming year.

Leonard B. Johnson, Chairman, Roosevelt Junior High, Milwaukee, Wis.

Alma Thomas, Vice-chairman Audubon Junior High, Cleveland, Ohio.

Carl F. Hanske, Secretary Manual Training High School, Indianapolis, Ind.

The meeting adjourned at 3:30 P.M.

ALMA THOMAS, *Secretary*

GEOGRAPHY SECTION

The Geography Section of the Central Association of Science and Mathematics Teachers met in room 1311 of the Hotel Lincoln on Friday afternoon November 30.

The chairman opened the meeting with the appointment of a Nominating Committee, consisting of Miss Mable Washburn of the Shortridge High School, Indianapolis, and Miss Helen Turner of the Oak Park-River Forest Township High School, Oak Park, Illinois.

The motto, "Let us have a more understanding heart—the understanding which comes from contacts made through travel," struck the key-note of the program. So much time is given to the technique of teaching and to methods of procedure that the vital thing, inspiration, is often over-looked. This program aimed to inspire teachers to make places real because they had seen them, and to understand peoples' actions because they had seen what conditions, both physical and social, had motivated those actions.

In the first paper, "A Summer in Spain," Miss Helen Turner of the Oak Park-River Forest Township High School of Oak Park, Illinois, gave a very delightful glimpse of Spain through pictures, as well as colorful description. She brought to the audience the real spirit of Spain in a most vivid manner. Her charming paper will appear in an issue of the magazine.

Dr. Harold C. Bryant, Assistant Director of the National Park Service, talked most delightfully and instructively from a series of beautifully tinted slides, illustrating our various National Parks. Dr. Bryant showed the great features of Geological interest found in the National Parks and explained how there one might study directly from the object rather than indirectly through the pages of a book. He continued by illustrating and explaining how not only Geology might be studied first-hand from nature, but also Botany in its various phases from the tiny Alpine flora to the oldest living things, the giant Sequoias in our National Parks. Bird and animal life also offer a rich field for study for the science student. Dr. Bryant may well be called the "Father of Nature Guiding in our National Parks." His talk pointed inspiringly to the possibilities and joys of the nature guiding field.

Many teachers do not need to be convinced of the essential place of travel in a well rounded education, particularly that of the Geographer. But they have the financial difficulty of having to travel on the limited income of a teacher. This objection was most cleverly and adequately met in a paper, "Gypsying on a Budget" by Mr. Robert Auble of the Arsenal Technical Schools, Indianapolis, Indiana. This delightful paper will appear in the magazine.

The closing number on the program was given by Mr. Robert B. Annis of Indianapolis, Indiana. He is a great lover of travel and has recorded many of his visits into unusual nooks in beautiful moving pictures. Three reels of these were shown: Craters of the Moon, The Grand Tetons, and Old Mexico. A generous and appreciative audience stayed overtime to pay their tribute to the joy and beauty of these pictures.

The following people, presented by the Nominating Committee were elected to serve for the following year: Chairman—Miss Helen Southgate, Michigan City, Indiana, Vice-Chairman—Mr. Howard Wright, Shortridge High School, Secretary—Mr. Virgil Petty, Indianapolis, Ind.

The meeting was adjourned until 1935.

VIVA DUTTON MARTIN, *Acting Secretary*

MATHEMATICS SECTION

The meeting of the Mathematics Section of the Central Association of Science and Mathematics Teachers was called to order by the chairman, Mr. D. T. Petty. In the absence of the secretary, Miss Bess Bauer, Mr. Petty appointed Mrs. Marie Wilcox as temporary secretary. A motion was made, seconded and carried to dispense with the reading of the minutes of last meeting of the section.

The president appointed a nominating committee as follows, Mr. E. W. Schreiber, Mr. Walter Carnahan and Miss Mary Potter.

The first paper of the afternoon was given by Professor Harold T. Davis of Indiana University on the subject, "How Periodic Elements are Discovered in Statistical Series," and was a mathematical supplement to his paper presented at the general session of the association Friday morning.

Professor Paul S. Dwyer of Antioch College, Yellow Springs, Ohio was the second speaker. His subject was, "The Crisis in High School and College Mathematics." Professor Dwyer acknowledged that lack of funds for proper teaching equipment and the position of mathematics in the secondary schools were among the current crises in mathematics. A more serious crisis, however, in his opinion, was the fact that civilization in its hour of need, is turning from mathematics, the aid that gives promise of success. Teachers of mathematics should emphasize the utilitarian value of their subject matter, according to Professor Dwyer. They must show that mathematics has many other uses besides its use in the physical sciences. He recommends that secondary schools teach those students who expect to attend college in different classes from those who do not expect to continue in higher mathematics. These college bound students would be offered a simpler course in which a higher degree of mastery is required. In conclusion, Professor Dwyer explained the method of teaching mathematics in Antioch College, which includes a large number of diagnostic tests and a system of individual instruction. The method prevails in both the technical and cultural mathematics courses in the college.

Professor Ernst Breslich, of the University High School of Chicago, followed Professor Dwyer with a paper on "Mathematics for Grades Seven, Eight and Nine." Much of the criticism of the traditional courses for these grades has not been groundless, according to Professor Breslich. However, the desirable improvements are being made by the reorganization of the curriculum of the grades seven through nine. The advantages of this reorganization are three fold. First, it will relieve the over-crowded high school course in mathematics. At the same time, the reorganization will put certain phases of algebra, geometry, and even trigonometry where they belong from the standpoint of learning and the needs of the learner. Finally, it makes possible the teaching in grades 7, 8, and 9, the arithmetic, geometry, and algebra which people in general should know, besides construc-

ting a foundation on which to build courses in algebra and geometry for those who will continue in the field of mathematics.

Professor Breslich outlined the courses used in the University High School in grades 7, 8, and 9. Although the course is by no means in its final stage, much may already be said in its favor, according to the speaker.

Following Dr. Breslich's paper, a general discussion was led by Mrs. Elsie Parker Johnson.

The nominating committee then reported the following nominations; for Chairman, Mr. J. R. McDonald of J. Sterling Morton High School of Cicero, Ill., for Vice-Chairman, Mr. C. J. Leonard of Southeastern High School, Detroit, Michigan, and for Secretary, Beulah Shoesmith of Hyde Park High School, Chicago, Ill. It was moved, seconded, and carried that the secretary cast a unanimous ballot to elect the entire slate.

Adjournment.

MARIE S. WILCOX, *Acting Secretary*

PHYSICS SECTION

The Physics Section was called to order at 1:35 P.M. by the Chairman, John H. McClellan. The first speaker was Dr. Mason E. Hufford of Indiana University, who read a paper on "The Romance of Research." A copy of his paper appears elsewhere in this issue of the Journal.

The second speaker was H. Clyde Krenerick of North Division High School, Milwaukee, Wis. He spoke on the subject, "The Single Laboratory Period a Demonstrated Success."

The third speaker was Earl R. Glenn of New Jersey State Teachers' College, Montclair, N. J. His subject was "The Place of Physics in the American Public School System." Professor Glenn made the following proposals for the consideration of the Association as a whole.

I. In order that an adequate program of science instruction may be developed for grades 1 to 12 there is needed a *coordinating committee* of the Association made up of two or three representatives of each section of the Association. This committee should be a standing committee to

(a) Hear reports on present tendencies in city and state course of study construction

(b) Hear reports on present tendencies in text construction for grades 1 to 12

(c) Develop policies for a program of instruction in science in all grades

(d) Issue reports on present day practices not approved by the Association.

II. In view of the great demands to be made on science teachers in the future increased attention should be given to the training now being given prospective teachers of science for elementary and high school classes. A new section is needed in the Association to deal with the problems involved in the training of teachers. All college and university teachers should be asked to join and assist in creating suitable courses and standards in this field, the same to be applied in granting permission to teach science in public schools.

III. In view of the studies now being made of science teaching, annual summaries should be prepared each year and distributed in the various sections. The facts and conclusions are needed in working out a coordinated program of science instruction for all grades. The Association should start this work in the near future.

The General Discussion was led by Thruman M. Huebner, Bowen High School, Chicago. At the end of his discussion he proposed a resolution concerning the teaching load of physics teachers. After some discussion from the floor, the resolution was passed unanimously and the secretary was instructed to send copies to William J. Bogan, Superintendent of Schools of Chicago and to Mr. Cleavenger, Secretary of the North Central Association of Colleges and Secondary Schools. A copy of the resolution as sent to the above persons is included in these minutes.

There was some discussion from the floor of Mr. Krenerick's paper on the single laboratory period. The sentiment seemed to favor the usual plan of double laboratory periods.

Mr. Krenerick spoke of a movement toward the abolition of physics and chemistry as separate subjects and the substitution of a course in physical science. He proposed a resolution, a copy of which is included with these minutes. After a brief discussion the resolution was passed unanimously and the secretary was instructed to send copies to William J. Bogan, Superintendent of Schools, Chicago and Mr. Cleavenger, Secretary of North Central Association of Colleges and Secondary Schools. A copy of the resolution as sent follows:

FIRST RESOLUTION

WHEREAS, there is a movement among the professors of education and in some of our universities and among the officers in the Education Department of some of our states to abolish Physics and Chemistry as distinct subjects and to substitute for them a rewritten combination of the two subject matters to be known as Physical Science I and Physical Science II, and

WHEREAS, the subjects of Physics and Chemistry as now presented are among the most popular elected subjects of the high school curriculum, and

WHEREAS, the content of these two subjects is of widely different nature, when presented in the approved manner requires distinctly differently equipped laboratories.

Therefore be it resolved, that the Physics Section of the Central Association of Science and Mathematics Teachers express its firm disapproval and determined opposition to this movement.

SECOND RESOLUTION

WHEREAS, the Physics Section of the Central Association of the Central Association of Science and Mathematics Teachers have recognized through their mutual experiences the difficulty of meeting practical subject as well as college entrance requirements in the allotted time and overloaded programs they now enjoy, be it hereby resolved that they go on record as advocating a reduction of teacher load to a maximum of four physics classes of thirty pupils each per day and of seven periods each per week or the equivalent.

There was some discussion of Mr. Glenn's proposal that the Association establish a section devoted to science teacher training. No action was taken by the section as it was thought that this was a matter to be considered by the Board of Directors and the General Session. Mr. Glenn stated that he would transmit to the Editor of the Journal a complete statement of his proposal so that it could be considered at the next annual meeting.

The nominating committee appointed by the chairman early in the meeting brought in the following nominations for officers of the section for the ensuing year:

For chairman: J. P. Coyle, Lane Technical High School, Chicago, Ill.
For vice chairman: Emil Massey, Central High School, Detroit, Mich.
For secretary: Charles Brosey, Arsenal Technical High School, Indianapolis, Ind.

The report of the committee was accepted. It was moved and seconded that the secretary be instructed to cast a unanimous ballot for the candidates.

The meeting was adjourned at 4:20 P.M.

WALTER E. PETERSON, *Secretary*

THE RECEPTION TEA

Following the section meetings the Annual Reception Tea was held in the Lincoln Room from four to six o'clock. This was served by the Indianapolis Chapter of the Council of Administrative Women in Education. This occasion particularly bore out the slogan "*Hearty Hoosier Hospitality*" which echoed everywhere throughout the convention.

THE TOURS

From three to five o'clock tours to various places of interest in Indianapolis were provided for those who desired to go. Other trips were provided for Saturday morning but the all day Saturday trip through Brown county, the Switzerland of Indiana, had to be given up on account of the muddy roads.

THE ANNUAL BANQUET

The annual banquet was held in the Travertine Room at six P.M., the banquet hall being packed to capacity. Piano and organ music were furnished by Christine Houseman of the Music Department of Shortridge High School, Indianapolis. Mrs. Bess S. Wright of the George Washington High School, Indianapolis, presented her Speaking Choir, a most beautiful and remarkable spectacle.

When the president introduced Dr. Otis W. Caldwell, toastmaster of the evening, she announced that the Board of Directors had voted to extend an Honorary Membership to Dr. Caldwell in recognition of his great service to the Association. He was one of the charter members of the Association and is its oldest living past president. All through the years he has contributed of his time and energy to forward the interests of the organization which he helped to create. Dr. Caldwell was genuinely surprised as the action of the Board had been kept a secret. He spoke on the subject of *Science Ahead of Us* and then in turn introduced each of the following speakers:

Dr. Paul Weatherwax, professor of botany, University of Indiana, substituting for Dr. Fernandus Payne, Dean of the Graduate School, University of Indiana, spoke on *Indiana's Noted Scientists*. This was followed by a pleasing address by Mr. F. E. Raschig of the Indianapolis Star who spoke on *Science and Mathematics in the Newspapers*. Then Dr. Will D. Howe of the Charles Scribner's Sons Publishing Company, of New York City, spoke on *Science and The New Public*. After this Dr. C. A. Ellis, Structural Engineering Department, Purdue University, who designed the bridge over the Golden Gate at San Francisco now in the process of construction, delivered an inspiring address on *Mathematics and Engineering Education*.

Then the evening's program was completed by a short address by Dr. W. L. Beauchamp, of the University of Chicago, on *The Philosophy of Science Teaching*.

THE SATURDAY MORNING WOMEN'S BREAKFAST

The Indianapolis Alumnae Association Pi Lambda Theta sponsored a breakfast for women members and wives of members attending the convention in the Lincoln Room, Saturday morning at seven o clock. The guests of honor were President Katharine Ulrich and Dr. Agnes E. Wells, Dean of Women, Indiana University. Dr. Wells gave the after breakfast address.

ANNUAL BUSINESS MEETING

The Annual Business Meeting was held in the Travertine Room at 8:15 A.M., Saturday morning, President Katharine Ulrich presiding. The Treasurer, Mr. Martin, and the Business Manager of the Journal, Mr. Roecker gave their reports.

Mr. W. W. Hart, Chairman of the Journal Committee gave the report of the Journal Committee and also of his committee auditing Mr. Roecker's books. He told of the excellent condition of the business manager's records and of the fine record in reducing the original debenture of $5000 to $2500. He also told of the fine work which Mr. Warner, the editor has done in making the Journal useful to the membership and of the willingness of the editor to receive suggestions for the improvement of the Journal.

Mr. Turton moved and it was seconded and carried that the report be accepted.

Mr. Metcalf's report on Year Books also commended the work of Mr. Roecker in keeping the year book record in the black instead of the red.

Mr. Carnahan made a brief statement regarding the audit of Mr. Martin's books which was also a commendation of their condition.

President Ulrich spoke of the fact that this convention was put on without any honoraria and very few expenses and suggested that the Journal carry a statement of the improved condition of the treasury.

Mr. Gingery in presenting his report of the Local Arrangements Committee stated that the work of putting on the Convention was done by parcelling out each job and that no one asked to be relieved. He spoke of the helpfulness of local organizations for civic educational welfare. The report was adopted with thanks.

Mrs. Wilcox in giving her report as chairman of the membership committee asked the coöperation of members in pointing out new members and suggesting workers.

Mr. Roecker spoke of the fact that the exhibitors were pleased with the placement of their exhibits.

Mr. Turton gave the report of the Necrology Committee.

Miss Hethershaw gave the report of the Resolutions Committee.

Mr. Roecker spoke for the Conservation Committee.

Miss Ulrich spoke for the Research Committee, stating that the work of the Research Committee is under the consideration of the Board of Directors.

Miss Ely gave the report of the Banquet Committee.

The Proposed Amendment XIII affecting Part III, section 1 and 4 of the Constitution was brought up and the motion made for its adoption lost.

Dr. Stone gave the report of the Place of Meeting Committee telling of the many cities offering invitations but moved that we meet in Chicago next year. This motion was seconded and carried.

Mr. Hadley took the chair and called for the report of the Nominating Committee which was given by Mr. Teeters who proposed the following slate of officers for the coming year:

President: Katharine Ulrich, Oak Park, Illinois
Vice-president: E. W. Christy, Cincinnati, Ohio
Members of the Board of Directors: O. D. Frank, Chicago; J. S. Georges, Chicago; Marie S. Wilcox, Indianapolis; W. G. Gingery, Indianapolis.

Mrs. Martin moved and it was seconded and carried that the slate made up by the nominating committee be elected.

Miss Ulrich spoke of the honor and responsibility which she felt in undertaking the work of the office for a second time and of the necessity of the membership working as a coöperative organization.

Dr. Stone moved that the meeting adjourn for the morning session, which motion was seconded and carried.

THE SATURDAY MORNING PROGRAM

The Saturday morning General Session opened in the Travertine Room at 9:30 A.M. with the Vice President, Joel Hadley, presiding.

Following the vocal solos by Maude Delbridge of George Washington High School, W. S. Howland, Assistant Professor of Sanitary Engineering, Purdue University, spoke on *Applications of Mathematics in Civil Engineering*. Then Mr. Roy M. Moffitt, Engineer with the Fairbanks Company of Chicago spoke on *The Mathematics and Science Behind Air Conditioning*. This was followed by an illustrated lecture on *Gold and Precious Stones Found in Indiana* by Mr. Frank B. Wade, Head of the Chemistry Department, Shortridge High School, Indianapolis. Then Dr. David Klein, President of the Wilson Laboratories of Chicago completed the program with a lecture on *You and Your Ductless Glands*.

THE SATURDAY AFTERNOON MEETING OF THE BOARD OF DIRECTORS

All newly elected officers, members of the Board of Directors, and other officers of the Association met for luncheon in the Italian Room at 12:30 where plans for the 1935 Convention were discussed. This developed into a formal meeting of the Board of Directors after the luncheon where among the items of business transacted of interest to the membership were the following:

Ira C. Davis and W. H. Carnahan were elected members of the Executive Committee.

Miss Ulrich announced the appointment of Mr. Hart as chairman of the Journal Committee.

It was decided to leave the exact place of meeting in Chicago in 1935 to the discretion of the Executive Committee and the members of the Board residing in Chicago.

The resignation of Mr. Bemisderfer as a member of the Board of Directors was accepted with regret and Mr. E. O. Bower elected in his place to fill out the unexpired term.

Combined report respectfully submitted.

ROSS B. WYNNE, *Secretary*

REPORT OF THE NECROLOGY COMMITTEE

The Necrology Committee records the names of two members; W. H. Grocott, of St. Louis and Sylvester Miller of Aurora, Ill. Mr. Grocott was born in St. Louis February 6, 1876 and died December 28, 1933. Following his education at and graduation from Washington University, he began teaching at the old Manual Training School. He was transferred to the Roosevelt High School, when that school opened in 1924, as an instructor

in Science and Mathematics. His teaching experience covered thirty-five years. He was a member of our association for 12 years and was much interested in its welfare.

Sylvester Miller was born in Bluffton, Indiana, March 4, 1877 and died in April 1933 at Aurora, Illinois. He received his B.S. Degree at Marion Normal College, obtaining further education at Valparaiso University, Indiana University and the University of Chicago. For the last fifteen years of his life he taught Physics in the West High School of Aurora. His qualifications entitled him to an instructorship in a college but he preferred to remain at Aurora. He was a tireless worker in school activities. He organized and directed the first band in the school. He was a radio enthusiast, forming a radio club for which he secured a federal license. By his pupils, the faculty and townspeople he was considered one of the very best teachers the school ever had. For fourteen years he was an active member of our Association.

Respectfully submitted,
CHAS. M. TURTON

TEACHERS IN ONE-ROOM SCHOOL DISTRICTS OF ILLINOIS IMPROVE IN TRAINING THOUGH PAY DECREASES GREATLY

We present in this Press Bulletin a table that represents a chapter in the school history of Illinois during the depression period that will speak well for the heroic teachers who have increased their efficiency in spite of the fact that their salaries have been reduced out of all proportion to the necessities of the case.

This table shows the qualifications of the teachers of one-room schools and their classification according to salaries for the school years ended June 30, 1932, 1933 and 1934.

A study of the state totals reveals the following interesting facts as to the increase in efficiency during the two worst years so far in the depression:

In 1932, 29.56% of the teachers had no training above the high school, while in 1934 only 9.88% were in that class. In 1932, 44.77% had one year's training above the high school, 19.42% had two years, 3.12% had three years and 3.13% had four or more years of such training; while in 1934, 49.44% had one year's training above the high school, 29.41% had two years, 5.02% had three years and 6.25% had four or more years of such training.

Now as to salaries we find the reverse holds true. For instance, in 1932 only .18% received less than $400 annual salary, 2.38% $400 to $500, 7.52% $500 to $600, 25.91% $600 to $700, 20.28% $700 to $800, 22.47% $800 to $900, 10.50% $900 to $1,000 and 10.76% $1,000 or more; while in 1934 6.46% received less than $400, 31.64% $400 to $500, 26.09% $500 to $600, 22.58% $600 to $700, 6.37% $700 to $800, 3.34% $800 to $900, 1.76% $900 to $1,000 and 1.76% $1,000 or more.

Under the NRA codes the commonest kinds of laborers are supposed to receive at least $728 a year, but most of the school boards of our one-room school districts seem to think that the services of 8,765 of the 10,101 teachers reported in this table are worth less than $700. It needs to be said in this connection that this low estimate of the teachers' value to the community is not limited to these 8,765 school districts, because a study of salaries of teachers in districts with two or more teachers shows that there are many teachers in those districts receiving less than $700 per year.

PROBLEM DEPARTMENT

CONDUCTED BY G. H. JAMISON
State Teachers College, Kirksville, Mo.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The editor of the department desires to serve its readers by making it interesting and helpful to them. Address suggestions and problems to G. H. Jamison, State Teachers College, Kirksville, Missouri.

SOLUTIONS AND PROBLEMS

Note. Persons sending in solutions and submitting problems for solutions should observe the following instructions.

1. Drawings in India ink should be on a separate page from the solution.

2. Give the solution to the problem which you propose if you have one and also the source and any known references to it.

3. In general when several solutions are correct, the one submitted in the best form will be used.

LATE SOLUTIONS

1359. *Thomas A. Pickett, Boston.*
1363. *C. S. Greenwood, T. A. Pickett, Boston.*
1361. *T. A. Pickett.*

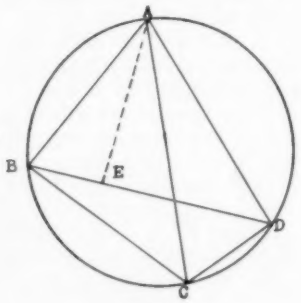
SOLUTION OF PROBLEMS

1364. *Proposed by Benjamin Braverman, Brooklyn, N. Y.*

In any inscribed quadrilateral the product of the diagonals equals the sum of the products of the opposite sides.

Solution by Roy MacKay, E. N. Mex. Junior College

This is Ptolemy's famous theorem and it is difficult to find a more elegant proof for it than the one usually given. (See for example Wentworth and Smith, Plane Geometry, p. 176, problem 11.)



Let $ABCD$ be an inscribed quadrilateral with diagonals AC and BD. Make angle BAE equal to angle CAD, then triangles BEA and AED are respectively similar to triangles CDA and ABC. From the resulting proportions it is easy to obtain

$$AC \cdot BE = AB \cdot CD \text{ and } AC \cdot ED = AD \cdot BC.$$

Addition gives the desired result, namely:

$$AC \cdot BD = AB \cdot CD + AD \cdot BC.$$

NOTE: Mr. Braveman observes that if the inscribed quadrilateral is a rectangle, with a and b as adjacent sides and c as diagonal that the Theorem of Pythagoras follows at once from Ptolemy's Theorem. The proof of Ptolemy's Theorem is also found in many geometry texts. Editor.

Solutions also were offered by W. E. Buker, Leetsdale, Pa., Richard A. Miller, University of Mississippi, Charles E. D'Amico, Albion, N. Y., J. E. Tuer, Orillia, Ontario, Jas. H. Schotland, N. Y. C., Maxwell Reade, Brooklyn, Glynden Easley, Portales, N. Mex., Chas. W. Trigg, Los Angeles; Walter H. Carnahan, Indianapolis, Ind., Cecil B. Read, Wichita, Kansas, Joseph L. Stearn, Washington D. C., and the proposer.

1365. *Proposed by E. S. Loomis, Cleveland, Ohio.*

A man having \$400 purchased 100 animals, giving \$8 a head for hogs, \$2 a head for sheep, \$1 a head for lambs, and \$9 a head for calves. In how many different ways can he purchase the 100 animals?

Solution by Anice Seybold, Monticello, Illinois

Let the initial letters of the words stand for the numbers of hogs, sheep, lambs and calves purchased. Then

$$8h+2s+l+9c=400$$

and

$$h+s+l+c=100.$$

It is easy to eliminate l and the result is

$$7h+s+8c=300, \tag{1}$$

where each of the unknowns must be a whole number greater than zero by the implications of the problem. This last equation is equivalent to the congruence,

$$7h+s \equiv 300 \pmod 8$$

which may be solved by the method given by Gustav Wertheim, *Elemente der Zahlentheorie*, Teubner, 1887, page 50. We may now write

$$7h+s \equiv 4 \pmod 8.$$

Then (2)
$$7h+s=4+8k$$

where k is a whole number. Since both h and $s \geqq 1$, $k \geqq 1$. Eliminating s and h between (1) and (2) and simplifying we have

$$c=37-k,$$

from which $k \leqq 36$.

There are, then, 36 values for k. Each of these gives one and only one integral value for $7h+s$, one and only one integral value for c, and consequently one and only one integral value for l. In all cases except the first one, s and h may have more than one value for each value of k. Consider, for example, $k=4$. Then

$$7h+s=36.$$

In this equation, h may have any integral value between 0 and 36/7, and s will have a corresponding integral value. When $k=4$ there are five sets of values for s and h. All five sets will correspond to one set of values for c and l. In the same way, it can be verified that values of k from 1 to 36 give the following series of numbers of answers: 1, 2, 3, 5, 6, 7, 8, 9, 10, 11, 13, 14, 15, 16, 17, 18, 19, 21, 22, 23, 24, 25, 26, 27, 29, 30, 31, 32, 33, 34, 35, 37, 38, 39, 40, 41. The sum of all these numbers is 761. Therefore there are 761 answers to the problem.

Editor's Note. The solution submitted contains 448 ways of purchasing the 100 animals each involving a negative number. Thus when $K=10$, there are 11 ways of making the purchase with only 10 ways having each letter a positive integer. The four numbers $h=1$, $s=77$, $z=-5$, $c=27$ satisfy the algebraic conditions set up but not the actual conditions. When 448 is deducted from 761 there remains 313 distinct ways of making the purchase. The proposer also offered a solution with the same result.

Solutions were offered by W. E. Buker and Norman Anning differing very little from 313.

1366. *Proposed by Norman Anning, University of Michigan.*

Show that the decimal fraction equivalent to the sum of the infinite series $1/10+2/100+3/1000+\ldots$ does not contain the digit 8.

Solution by J. E. Tuer, Orillia, Ontario, Canada

$$S=1/10+2/100+3/1000+\cdots \text{ and}$$

$$1/10S=1/100+2/1000+\cdots. \text{ Subtracting,}$$

$$9/10S=1/10+1/100+1/1000+\cdots$$

$$\therefore \quad 9/10S=1/9,$$

by use of Formula for sum of an infinite geometric series $S=1/9\times 10/9=10/81=0.\dot{1}23456790\dot{}$, by actual division. Hence, since S reduces to a repeating decimal with the period as given, no "8" appears.

Solutions also offered by Roy MacKay, Portales, N. Mex., Charles W. Trigg, Los Angeles, H. D. Grossman, N. Y. C., W. E. Buker, Leetsdale, Pa., Aaron Buchman, Buffalo, N. Y., Maxwell Reade, Brooklyn, and the proposer.

1367. *Proposed by the Solid Geometry Class, Centralia (Ill.) Township High School.*

If a cube C can be divided into equal sub cubes, the ratio of the number of sub cubes having no faces and those having three faces in the surface of C, is equal to the cube of the ratio of the number of sub cubes having one face and those having two faces on the surface of C.

Solution by Frank Kurtz, Hirsch High School, Chicago, Ill.

Let N represent the number of sub cubes along any edge of C. Then $(N-2)^3$ is the number with no face on the surface of C, and, $6(N-2)^2$ is the number with one face on the surface of C, and, $12(N-2)$ is the number with two faces on the surface of C, and, 8 is the number with three faces on the surface of C, and the ratios are:

$$\frac{(N-2)^3}{8}=\left(\frac{6(N-2)^2}{12(N-2)}\right)^3 \tag{1}$$

$$\frac{(N-2)^3}{8}=\frac{(N-2)^6}{8(N-2)^3} \tag{2}$$

$$\frac{(N-2)^3}{8}=\frac{(N-2)^3}{8}. \tag{3}$$

Since equation (3) is an identity, equation (1) is true.

Solutions also offered by Maxwell Reade, Brooklyn, W. E. Buker, Leetsdale, Pa., Aaron Buchman, Buffalo, N. Y., Roy MacKay, Portales, N. Mex., and Charles W. Trigg.

1368. *Proposed by Dewey C. Duncan, University of California.*

Show that, for just one real value of a, the equation $ax^4+(x-1)^3=0$ has a double root. Find the value of a and the roots of the equation.

Solution by Norman Anning, University of Michigan

The given equation has repeated roots if $ax^4+(x-1)^3$ and its first derivative, $4ax^3+3(x-1)^2$, have factors in common. Any factor which they have in common will be a factor of

$$4\{ax^4+(x-1)^3\}-x\{4ax^3+3(x-1)^2\}$$

which reduces to $(x-1)^2(x-4)$.

The given equation has 1 as a *triple* root when $a=0$.

The given equation will have 4 as a repeated root if we choose a so that $256a+27=0$, $a=(-27/256)$. Then $27x^4-256(x-1)^3=0$,

$$(x-4)^2(27x^2-40x+16)=0.$$

Here 4 is a *double* root and the roots of the remaining quadratic equation are readily found.

A solution was also offered by Roy MacKay, Portales, N. Mex.

1369. *Proposed by Hugh L. Dimmer, Custer, South Dakota.*

(a). A plumber wishes to erect piping from the lower corner to the opposite upper corner of a room 20 feet long, 15 feet wide, and 10 feet high. The piping is to be laid along the walls, floor and ceiling, What is the shortest length of piping necessary?

(b). Assuming a general case of the above problem, with $h<w<l$, should the piping be laid along the (1) floor and side wall, (2) floor and end wall, or (3) side wall and end wall, in order to use the shortest length of piping? Prove.

Solution by Charles W. Trigg, Cumnock College, Los Angeles

(a) This is a special case of (b) where $h=10$, $w=15$, and $l=20$ feet. Hence the shortest length of piping necessary is $\sqrt{20^2+25^2}=\sqrt{1025}=32.0156$ feet.

(b) The piping laid along the floor and side wall will be of the same length as the hypotenuse of a right triangle formed by folding the side wall down into the plane of the floor and joining the corners under consideration.

$$M=\sqrt{l^2+(w+h)^2}=\sqrt{l^2+w^2+h^2+2wh}.$$

Similarly, if the piping be laid along the floor and end wall,

$$N=\sqrt{w^2+(l+h)^2}=\sqrt{l^2+w^2+h^2+2lh}.$$

If the piping be laid along the end and side walls,

$$P=\sqrt{h^2+(l+w)^2}=\sqrt{l^2+w^2+h^2+2lw}.$$

Since $h<w<l$, $wh<wl$, $wh<lh$, $lh<wl$, so $wh<lh<lw$. Hence, $M^2<N^2<P^2$ and $M<N<P$. Therefore, in order to use the shortest length of piping, it should be laid along the floor and side wall. Side wall and ceiling would be preferable and even then pity the poor plumber who had to find an elbow with which to make the bend.

Solutions were also offered by W. E. Buker, Leetsdale, Pa., Charles C. D'Amico, Albion, N. Y., Hobson M. Zerbi, Wilkes-Barre, Pa., W. R. Smith, Chicago, Maxwell Reade, Brooklyn, N. Y., and the proposer.

HIGH SCHOOL HONOR ROLL

The editor will be very happy to make special mention of high school classes, clubs, or individual students who offer solutions to problems submitted in this department. Teachers are urged to report to the Editor such solutions.

For this issue the Honor Roll appears below:

HONORABLE MENTION

1369. Norwood (Ohio) H. S. Class in Geometry,

1367. Centralia (Ill.) Township H. S.; Ralph Bushee, Jr. and Chas. McIntosh, Monticello, Ill.

PROBLEMS FOR SOLUTION

1382. *By Charles W. Trigg.*

Resolve $x^8+398x^4y^4+y^8$ into two polynomial factors with integral exponents.

1383. *Proposed by D. C. Duncan, University of California.*

The points of intersection of the two external tangents, the two internal tangents and the centers of the two circles are four harmonic points.

1384. *Proposed by W. E. Buker, Leetsdale, Pa.*

A sphere is tangent to each of two skew lines. Find the locus of its center.

1385. *Proposed by Maxwell Reade, Brooklyn, N. Y.*

Given a trapezoid $ACDF$ with AF and DC parallel. Also EB is drawn parallel to DC with $\frac{AB}{BC}=\frac{a}{b}$. Let $FA=m$, $DC=n$. Prove $BE=\frac{an+bm}{a+b}$.

1386. *Proposed by Walter H. Carnahan, Indianapolis, Ind.*

Show that the area of a quadrilateral inscribed in a circle equals $\sqrt{(s-a)(s-b)(s-c)(s-d)}$ where a, b, c and d, are the sides of the quadrilateral and $2s=a+b+c+d$.

1387. *Proposed by H. C. Torreyson, Chicago, Illinois.*

What is the greatest number of spherical balls each exactly one inch in diameter that can be placed inside a rectangular parallelopiped having its inside dimensions exactly $7''\times9''\times9''$?

SCIENCE QUESTIONS

March, 1935

Conducted by Franklin T. Jones, 10109 Wilbur Avenue, Cleveland, Ohio.

Readers of School Science and Mathematics are asked to contribute: Questions, Answers, Comments, Suggestions—Whatever is new or interesting in the teaching of Science.

Wanted—Your mid-year examination papers. Thanks! Mail them.—Do it now.

Your classes and yourself are invited to join the GQRA (Guild Question Raisers and Answerers). More than 50 others have already been admitted to membership by answering a question or proposing one that is published.

Answers are lacking to Questions 669, 670, 671, 672, 673. Submit them to your classes; send in the answers.

BECOME MEMBERS OF THE GQRA

RALLY OF SCIENCE & MATHEMATICS TEACHERS

Western Reserve Academy, Hudson, Ohio Saturday, March 16, 1935.

All day!!

Cap'n Bill Vinal's Nature Guide School.

Simon's Maple Sugar Bush.

Maple Sugar Supper at Congregational Church.

Discussion:

"SOCIAL SCIENCE AND/OR OUR PRESENT SCIENCE AND MATHEMATICS." PRO AND CON—WHICH?

ENGINEERS DISAGREE

689. *Proposed by John C. Packard, (GQRA No. 1) Brookline, Mass.*

Reported to me that two college men argued for two hours over this problem. A $1\frac{1}{4}$ in. pipe, with strainer attached, is driven into the ground for an artesian well. Water rises to within 20 ft. of the top of the pipe. It is proposed to use an electric pump, having a $\frac{3}{4}$ in. supply pipe attached, to bring the water to the surface. Query: should the supply pipe be attached, direct, to the top of the $1\frac{1}{4}$ in. pipe by a reduced coupling or should the $\frac{3}{4}$ in. supply pipe be made long enough to reach down into the water and be placed inside the $1\frac{1}{4}$ in. pipe? Why?

ED. JONES paid a plumber for 15 hours work for fixing a pump that was connected up wrong as intimated above. The plumber "repaired the valves." What should he have done? Actually, the next time he brought a second plumber to help him. Now, after pumping a pail-and-a-half of water, pumping stops. Why? After priming you can start the pump and get another pail-and-a-half. How much should ED pay the second plumber?

CLAIMED AS PHYSICS PROBLEMS

690. *Proposed by Maxwell Reade, (GQRA, No. 47) Brooklyn, N.Y.*

"Here are two cute problems."

I. The velocity of the extremity of the minute hand is 16 times that of the hour hand, which is 3 inches long. How long is the minute hand?

II. A train is running on a horizontal track at 30 m.p.h. when the steam is suddenly shut off. How far will train run before it stops? (If the resistance to its motion is equal to 16 lb. force per ton of mass of train.)

691. *Proposed by Brother Felix John, (GQRA No. 18) La Salle College, Philadelphia, Pa.*

A piece of rope weighs four ounces per foot. It is passed over a pulley

and on one end is suspended a weight and the other end a monkey. The whole system is in equilibrium.

The weight of the monkey in pounds is equal to his mother's age in years. The age of the monkey's mother added to the age of the monkey is four years. (1) The monkey's mother is twice as old as the monkey was when (2) the monkeys mother was half as old as the monkey will be when (3) the monkey is three times as old as the monkey's mother was when (4) the monkey's mother was three times as old as the monkey.

The weight of the rope or the weight at the end is half as much again as the difference between the weight and the weight plus the weight of the monkey. How long is the rope?

A TEST FROM THE PHILIPPINES

692. *Submitted by Miss Luz A. Santos (GQRA, No. 43) Physics Teacher and Chairman, Dept. of Sciences, Rizal High School, Pasig, Rizal, P. I.*

Test I—True–False (Will be published if requested)

Test II—Matching

Part A. Men and their contributions.

Directions: On the line provided write the *number* of the item at the left that will match with the item at the right.

1. Galileo	_____	1. Determination of pi
2. Mayer	_____	2. Air pump
3. Archimedes	_____	3. Absolute scale of temperature
4. Newton	_____	4. Conservation of energy
5. Henry	_____	5. Laws of motion
6. Kelvin	_____	6. Mechanical equivalent of heat
7. Otto Von Guericke	_____	7. Laws of falling bodies
8. Hooke	_____	8. Spring balance
9. Piccard	_____	9. Centigrade scale of temperature
10. Perrier	_____	10. Relation between absorption and pressure
11. Joule		
12. Celsius		

Score: No. right_____

Part B. Instruments.

Directions: Write on the line provided the *number* of the term at the left that is identified by the phrase at the right.

1. calorimeter	_____	1. Liquid pressure
2. thermometer	_____	2. force
3. dilamometer	_____	3. heat quantity
4. siphon	_____	4. coefficient of expansion of liquids
5. pressure gauge	_____	5. transferring liquids from immovable vessels
6. barometer		
7. hydrometer	_____	6. sp. gr. of liquids
8. dynamometer	_____	7. air pressure
9. altimeter	_____	8. temperature
10. conductometer	_____	9. device used to determine the acceleration of gravity
11. hygrometer		
12. hydraulic press	_____	10. an application of Pascal's law
13. pendulum		
14. balloon		

Score: No. right_____

Test III—Multiple Choice (Published on Request)
Test IV—Completion (Published on request)
Test V—Problems (Published on request)

(The above series was used in Rizal High School
FOURTH YEAR PHYSICS—
Departmental Test for the Second Grading Period)

693. *Submitted by Carroll E. Lowe (GQRA, No. 10) Brookline High School, Brookline, Mass.*

JUNIOR PHYSICS MID-YEAR EXAMINATION

On composition paper, answer *any twelve* questions:

1. Designate as "true" or "false" but *do not* copy:
   (a) Zinc is a magnetic metal.
   (b) An ammeter always should be connected in series.
   (c) A transformer converts alternating into direct current.
   (d) An A.C. generator requires an exciter for its field magnet.
   (e) The modern vacuum tube used in radio was invented by Marconi.
2. Below is a list of substances some of which could be used in making a dry cell. Choose those which should be used and make a *revised list*, omitting all substances not needed:

Sheet copper	Sealing wax	Glass rod
Sheet zinc	Blotting paper	Iron rod
Sheet tin	Carbon rod	Sal ammoniac
Water	Granulated carbon	Manganese dioxide

3. Each of the following statements has at least one incorrect term. *Copy all* the statements but replace all incorrect terms with those which will render the statements correct:
   (a) Like poles attract; unlike poles repel.
   (b) The resistance of a conductor is inversely proportional to its length.
   (c) An electric current in a wire is merely a flow of ions.
   (d) Polarization in a cell is the formation of oxygen bubbles on the positive plate.
   (e) When the external resistance is high, cells of any kind should be connected in parallel.
4. *Copy and complete* the following statements:
   (a) An electrical safety valve is called a _____.
   (b) Three types of chemical compounds recognized as electrolytes are _____.
   (c) _____ is a process is which molecules split up into ions when a substance enters solution.
   (d) The _____ is the positive terminal of an electrolytic cell.
   (e) Three methods of producing radio waves are by_____ by_____, or by_____.
5. Three electric lamps are connected in series. The voltage across each is 35 volts, and the current flowing through the combination is 0.2 amperes.
   (a) Find the total voltage.
   (b) Find the resistance of one of the lamps.
   (c) Find the resistance of the combination.
6. (a) What three things determine the strength of an electromagnet?
   (b) Name the four factors that govern the electrical resistance of a conductor.
7. Below is a list of electrical devices. Choose those which are necessary in any station of a simple relay telegraph line, and make a *revised list*. *Omit all* that are unnecessary:

Induction coil	Relay	Key

Sounder	Commutator	Line Wire
Battery	Exciter	Vacuum tube

8. A transformer has a primary coil of 300 turns and a secondary coil of 1800 turns. If the voltage across the primary is 110 volts, find the following:
   (a) The voltage across the secondary.
   (b) The proper name for the transformer.
9. (a) During charging, what compound is formed on the positive plate of a storage battery?
   (b) During discharging, what compound forms on both plates?
   (c) During charging, what change takes place in the electrolyte?
   (d) List five important uses for the storage battery.
10. Using electrical symbols, draw an accurate diagram of a crystal-detector radio receiver.
    (b) Name five varieties of crystals that can be used in such a receiver.
11. The ammeter of a certain circuit reads 15 amperes while the voltmeter indicates 110 volts.
    (a) How much power in watts is developed?
    (b) How much power in kilowatts?
    (c) If current is drawn for 24 hours, how many kilowatt hours of electrical energy would be used?
12. (a) Draw an electrical diagram showing a D.C. generator connected so that it can deliver current to four lamps in parallel.
    (b) In the circuit draw an ammeter so placed that it will show the total current flowing.
    (c) Draw a voltmeter in position to show the voltage across the lamps when they are lighted.
    (d) Include a switch that can be used to turn all lamps on or off.
13. During the process of electroplating, what facts should be remembered relative to the:
    (a) Current? (c) Anode?
    (b) Electrolyte? (d) Cathode?
14. (a) Draw a carefully rendered diagram of a single tube radio receiver. Use electrical symbols.
    (b) Would it be possible to operate a loud speaker with such a receiver? Why?
    (c) Suggest how we could make it possible to operate a loud speaker with great volume of sound.

Have all questions *in order* and *correctly numbered*.
Fold papers lengthwise in the center.
Put your name on the outside after folding.
Below your name, write your division.
Below your division, indicate the name of your instructor.

TOO EASY QUESTIONS

"Why the Failures?" asks a teacher—
(a continuation of questions separately numbered which were originally published as No. 643.)

694. (11) A lever 6 feet long has its fulcrum 6 inches from one end. What is its mechanical advantage?

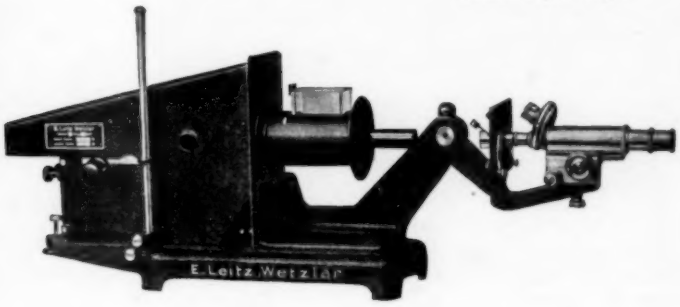
695. (12) How much work is done in pushing a 100-pound trunk 4 feet along the floor with a force of 40 pounds?

Leitz

MICRO PROJECTOR

XB NEW MODEL

Microprojector XB with vertical object stage.



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696. (13) Define foot-pound.

697. (14) A highway with a 2% grade rises _____feet in a mile.

698. (15) State Archimedes' principle.

Please try out the above five questions and send in specimen answers. Answers that are published will enroll the writer in the GQRA. Join!! Please do the same with 669 to 673 inclusive (October 1934).

NATURE QUESTIONS

By Ross McConnehey

1. What shape are the owl's eggs?
2. What color is the flower of blood-root?
3. In the rainbow is the blue color above or below the red?
4. A gull's eggs are round at one end but taper to almost a blunt point at the other. Why?
5. What color are the baby turkey buzzards?
6. What are polliwogs?
7. In what part of the sky do you see the new moon?
8. What is the appearance of the fruit of Jack-in-the-pulpit?
9. What is the taste of the root bulb of Jack-in-the-pulpit?
10. In what part of the sky are the planets?
11. How can poison ivy be distinguished from the non-poisonous ivy?
12. What insect helps the farmer raise his clover crop?
13. How can you distinguish a white-oak tree from a red-oak tree?
14. What difference is there between the manner in which a horse and a cow crop grass?
15. Why do the foresters destroy all the wild goose-berry bushes?
16. In what part of the sky does a rainbow appear in the morning?
17. In what part of the sky is the big dipper at nine o'clock in the evening?
18. On which side of a tree are you most likely to find moss growing?
19. How does a locust sing its song?
20. How does a katy-did produce its sounds?
21. What are tadpoles?
22. Where are a chicken's thumbs?
23. What planet is the brightest?
24. What are the "eyes" on a potato?
25. How does a sweet pea plant climb a string?
26. Why is Venus always a "morning" or an "evening star"?
27. If a bee stings you does it hurt the bee?
28. How does a fly hold to a pane of glass?
29. How can you tell a three-year-old hen from one only one year old?
30. Why does a strong turnip "bite" when you bite it?
31. Why are celery stalks white?
32. Do frogs have teeth?
33. How can a farmer tell a young horse from an old one by looking at his teeth?
34. Draw the shape of the "Big Dipper."
35. Show how to find the North Star by use of the Big Dipper.
36. What plant was used by the early residents of the Central States for making ink?
37. What two plants now furnish most of the sugar used?
38. What plant furnished the early residents of America most of their sugar?
39. Do toads have teeth?
40. What makes a bell pepper "hot"?

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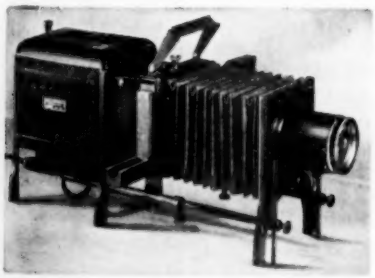

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BOOKS AND PAMPHLETS RECEIVED

Trend Analysis of Statistics by Sasuly. Cloth. Pages xiii+421. 15×24 cm. 1934. The Brookings Institution, Washington, D. C.

Economic Geography, by R. H. Whitbeck, Professor of Geography, University of Wisconsin, and V. C. Finch, Professor of Geography, University of Wisconsin. Third Edition. Cloth. Pages x+565. 14×23 cm. 1935. McGraw-Hill Book Company, 330 West 42nd Street, New York, N. Y. Price $3.50.

Electrons (+ and −), Protons, Photons, Neutrons, and Cosmic Rays, by Robert Andrews Millikan, Formerly Professor of Physics at the University of Chicago, and now Director, Norman Bridge Laboratory of Physics, California Institute of Technology. Cloth. Pages x+492. 12.5×18.5 cm. 1935. University of Chicago Press, 5750 Ellis Avenue, Chicago, Illinois. Price $3.50.

Before the Dawn of History, by Charles R. Knight. Cloth. Pages xiii +119. 23×30 cm. 1935. Published by Whittlesey House, McGraw-Hill Building, 330 West 42nd Street, New York, N. Y. Price $2.50.

Trees of North America (exclusive of Mexico), by George Rex Green, Professor of Nature Education, The Pennsylvania State College. Volume II, The Broadleaves. Cloth. Pages xvii+344. 21×27 cm. 1934. Edwards Brothers, Inc., Ann Arbor, Michigan. Price $3.50.

La Régle A Calcul, by M. A. Sainte-Laguë, Assistant Professor of Lycée Janson-de-Sailly, and Associate Director of l'École des Hautes Études. Paper. 34 pages. 18×26.5 cm. Librairie de l'Enseignement Technique, Léon Eyrolles, Éditeur, 3 rue Thénard, Paris (V°). Price 5 Frs.

Differential Geometry, by William C. Graustein, Professor of Mathematics, Harvard University. Cloth. Pages xi+230. 14×21.5 cm. 1935. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $3.00.

The Education of Children in the Primary Grades, by John Louis Horn, Professor of Education, Mills College, and Thomas White Chapman, Assistant Superintendent in Charge of Instruction, Public Schools, Lodi, California. Cloth. Pages ix+291. 13×20.5 cm. 1935. Farrar and Rinehart, 508 West 26th Street, New York, N. Y.

Progressive Plane Geometry, by Webster Wells, Author of a Series of Texts on Mathematics, and Walter W. Hart, Associate Professor of Mathematics, School of Education and Teacher of Mathematics, Wisconsin High School, University of Wisconsin. Cloth. Pages ix+390. 12.5 ×19 cm. 1935. D. C. Heath and Company, 285 Columbus Avenue, Boston, Massachusetts. Price $1.36.

Biology, by Frederick L. Fitzpatrick, Associate Professor of Natural Sciences, Teachers College, Columbia University, New York, and Ralph E. Horton, Chairman of the Department of Science, Seward Park High School. New York City. Cloth. Pages xiv+611+xlv. 13.5×19 cm. 1935. Houghton Mifflin Company, 2 Park Street, Boston, Massachusetts. Price $1.76.

Brief Analytic Geometry, by Thomas E. Mason, professor of Mathematics, Purdue University, and Clifton T. Hazard, Associate Professor of Mathematics, Purdue University. Cloth. Pages xi+196. 14×21 cm. 1935. Ginn and Company, 15 Ashburton Place, Boston, Massachusetts. Price $2.00.

Second-Year Algebra, by Herbert E. Hawkes, Professor of Mathematics in Columbia University; William A. Luby, Head of the Department of Mathematics in the University of Kansas City; and Frank C. Touton, Professor of Education in the University of Southern California. Cloth.

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Life & Casualty Building, Nashville, Tenn.

Pages vii+360+vi. 12.5×19 cm. 1935. Ginn and Company, 15 Ashburton Place, Boston, Massachusetts. Price $1.24.

Physics of the Home, A Textbook for Students of Home Economics, by Frederick A. Osborn, Professor of Physics, University of Washington. Third Edition. Cloth. Pages xii:441. 13.5×20.5 cm. 1935. McGraw-Hill Book Company, 330 West 42nd Street, New York, N. Y. Price $3.00.

Useful Science for High School, by Henry T. Weed, Head of the Science Department, Girls' Commercial High School, Brooklyn, New York; Frank A. Rexford, Educational Director, Museum of the City of New York; and Franklin B. Carroll, Head Department of Science, Frankford High School, Philadelphia, Pa. Price $1.68.

The Relationship Between the Ability to Recall and the Ability to Infer in Specific Learning Situations, by Ralph C. Bedell, Assistant Professor of Education, Northeast Missouri State Teachers College, Kirksville, Missouri. Paper. 55 pages. 15×23 cm. Bulletin of the Northeast Missouri State Teachers College, Kirksville, Missouri. Volume XXXIV, Number 9 December, 1934. Price $1.00.

Nature Education: A Selected Bibliography, by William Gould Vinal, Curriculum Laboratory, School of Education, Western Reserve University. 1935. 82 pages (mimeographed). 75 cents, plus postage. Lots of 10 or more 30% off.

Some Principles of Elementary Inorganic Chemistry, by B. Clifford Hendricks, Department of Chemistry, University of Nebraska. Pamphlet. 4 pages. 22×28 cm. A copy will be sent on application with postage, 3 cents.

BOOK REVIEWS

Man and the Nature of His Biological World, by Frank Covert Jean, Ezra Clarence Harrah, and Fred Louis Herman of the Colorado State Teachers College, with the collaboration of Samuel Ralph Powers, Teachers College, Columbia University. 599 pp., 236 figures. Ginn and Company. $2.40. 1934.

The production of this work represents the response to a specific demand. College administrators have stressed from time to time, and especially in recent years, the need for introductory courses in science suited to meeting the needs of the masses as well as those of the comparatively few who are to become specialists in some particular field of the science. In fact, it is increasingly common for schools to require in the junior college certain of these non-technical general courses for their value to students who go no farther and as a foundation for the specialized training of those who go on to the university.

There may be a difference of opinion among biologists interested in this type of course as to the biological materials best suited to the organization and development of the course. There can be no question as to the guiding principle in the minds of these authors. Man is the central figure in the biological world upon which he depends and which he gradually learns to control.

The material is organized around six significant units. Appended to each unit there are questions for study and a list of references. The book is suited as a text to be used in a one-semester lecture-demonstration course with some opportunity given for contact with real materials. The book is highly recommended for use in the type of course which it develops.

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Man and the Nature of His Physical Universe, by Frank Covert Jean, Ezra Clarence Harrah, and Fred Louis Herman, Colorado State Teachers College with the Editorial Collaboration of Samuel Ralph Powers, Teachers College, Columbia University. Cloth. Pages x+524. 14×20.5 cm. 1934. Ginn and Company, 15 Ashburton Place, Boston, Massachusetts. Price $2.20 each.

This is the companion volume to the one described by Mr. Isenbarger above, and with it forms the textual material for a survey or orientation course in natural science for junior college classes. Selection of the material for such a course is an important and difficult problem. That the authors have a clear understanding of the purposes of such a course is evident from the preface of the book where they state that such courses "shall help the student to locate himself in the universe; that they shall help to free him from superstition and prejudice; that they shall teach him to rely upon established truth in ordering his own life and to value the leadership of the specialist; that they shall enable him to appreciate the careful, logical methods employed by the scientist in arriving at trustworthy conclusions; in short, that the generalizations of science shall be presented in such a way as to influence in a significant manner the beliefs, philosophy, and attitudes of the average student."

The subject matter selected will certainly contribute to these aims if presented by an enthusiastic, skillful teacher. No doubt the method of presentation is more important in attaining some of the goals than the subject matter employed. But if students are to have no further opportunity for systematic science study under expert guidance it is highly important that the subject matter be chosen to lead the student to the real foundations of science. If this criterion be used we are forced to conclude that the text is lacking in the great developments of modern physical science, that the wonderful recent discoveries in atomic physics, electronics, and modern chemistry have been sacrificed in order to give space for the mighty grandeur of astronomical and geological phenomena and features. The latter are truly interesting and more easily presented but they are further removed from our daily lives. The reviewer cannot refrain from pointing out a second serious fault, namely, an unusual number of erroneous or misleading statements. We are led to believe that a north magnetic pole attracts a stream of electrons and a south pole repels it; that the Bohr atom is a static atom; that, "Two of the most important forms of force and energy in modern life are magnetism and electricity respectively. Each is easily transformed into the other." In spite of this criticism the text ranks high in its field and is worthy of the attention of any one interested in the developing survey courses. It will stand as one of the pioneers.

G. W. W.

Super Calculation, by John R. Harold, 111 North Street, San Antonio Texas. Paper. Pages vi+108. 13×19 cm. 1931.

Super Calculation or Arithmetic Modernized as this little book is designated represents a departure from current methods in performing arithmetical calculations. It gives many short cuts which are very striking and effective, and should be valuable to teachers and pupils interested in working with numbers. In addition to rapid calculations of the fundamental operations involving integers, decimals and fractions, rapid and accurate methods of computing interest, profit and loss, discounts, finding areas, volumes of solids, etc., are presented.

The reviewer feels that this little book should find a place on the mathematics shelves of every school library. Certainly it should be a part of

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C. A. STONE

Solid Geometry, by Elizabeth Buchanan Cowley, Teacher of Mathematics, Allegheny Senior High School, Pittsburgh, Pa. Cloth. Pages ix+230. 12.5×18.5 cm. 1934. Silver Burdett and Company, 39 Division Street, Newark, New Jersey. Price $1.28.

This book should find favor with teachers of solid geometry since it is written in simple language, and great care is exercised in the development of new terms. There are many interesting illustrations and pictures. The drawings are clear and well drawn and should prove helpful to the student.

The text is divided into three parts following the traditional organization and each part or book concludes with a testing program including matching and multiple choice tests. Theorems are arranged in groups with a common geometric concept underlying each group. The exercises in each group are well graded and stress the relationship of solid geometry to other school subjects and to various phases of modern life outside of the classroom.

The book satisfies the major requirements of the college Entrance Board, The Recommendations of the National Committee and the requirements of the New York State Syllabus. To meet the varying needs and capacities of students for a semester's course in solid geometry six plans are suggested in the preface.

C. A. STONE

The Teaching of Chemistry, by N. F. Newberry, Chemistry Master, Oldershaw School, Wallasey, England. Cloth. Pages xi+247. 1934. William Heinemann, Ltd. 99 Great Russell Street, London, W.C.I. Price six shillings.

While this book is written primarily for English chemistry teachers it is so applicable to schools in the United States that any teacher of high school chemistry will profit greatly by reading it. In fact much of the time he will feel that the discussions were written to help him in his own particular difficulties. The topics treated are those the beginning teacher needs to have discussed and the treatment is lucid and eminently practical. The extensive bibliography includes many books and magazine articles with whose titles many teachers in this country are not familiar.

E. R. D.

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